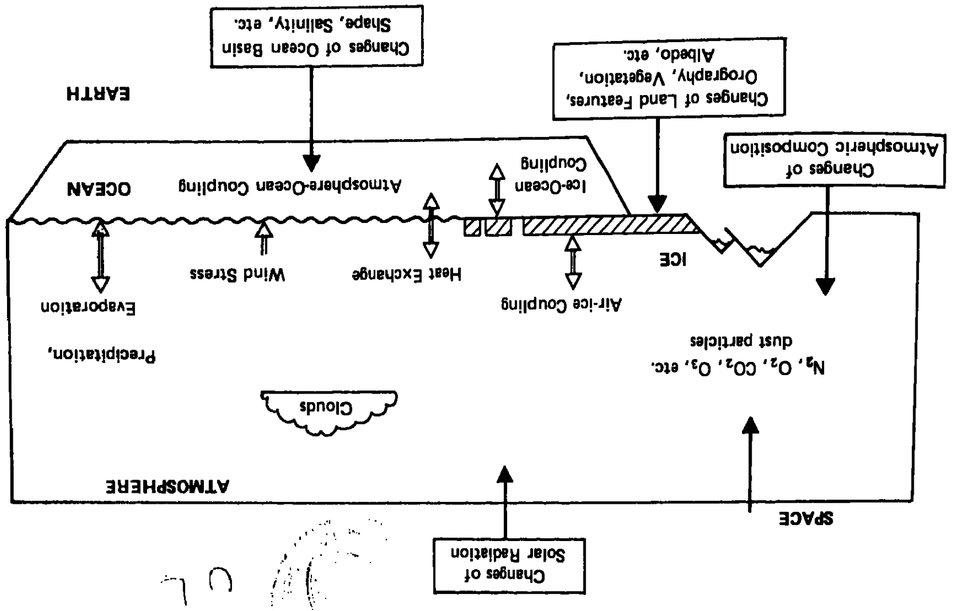

TRANSACTIONS, AMERICAN GEOPHYSICAL UNION
VOLUME 62 NUMBER 51 DECEMBER 22, 1981

Meetings

Precipitation Variations

How precipitation varies with space and time during individual storms will be discussed during an all-day symposium at the 1982 AGU Spring Meeting from May 31 to June 4, in Philadelphia, Pa. The symposium, sponsored by the Precipitation Committee of the Hydrology Section, will provide a forum for the presentation of recent research results on the formulas and area-depth-duration relations of rainfall. These describe the manner in which precipitation amounts vary, over the earth's surface and with time, in an individual rain cell, a single shower or thunderstorm, or a short rainstorm lasting much less than a day. The symposium will complement the AGU Chapman Conference on Rainfall Rates, to be held April 27–29 in Urbana, Ill.

Papers should emphasize practical applications to problems in runoff forecasting, drainage design, and rain-gauge networks, as well as storm dynamics. Abstracts, in standard AGU format, should be mailed to the symposium chairman, Jaime Amorocho, Department of Civil Engineering, University of California, Davis, CA 95616; deadline is February 15. In addition, the abstract original must be sent to Meetings, AGU, 2000 Florida Ave., N.W., Washington, D.C. 20009 by the Spring Meeting abstract deadline, March 10. Additional information can be obtained from Amorocho (telephone: 916-752-0685) or the associate chairman, David Hershfield, Hydrology Laboratory, SEA/AR, Bellsville, MD 20705 (telephone: 301-344-3941). ⊠

Shear Waves and Pattern Recognition

The third biennial SEG/USN Joint Technical Symposium will be held March 22–23 in Building 1200 of the National Space Technology Laboratories in Bay St. Louis, Miss. The symposium, sponsored by the Office of Naval Research and the Society of Exploration Geophysicists, will be hosted by the Naval Ocean Research and Development Activity (NORDA) and will be held in conjunction with NORDA's workshop entitled 'Pattern Analysis in the Marine Environment' (March 24–25).

The symposium's two themes are shear waves and pattern recognition in the marine environment. Among the topics to be discussed are detection and measurement techniques in marine and nonmarine environments; shear wave energy partitioning at transitional boundaries and effects on transmission/reflection losses in the marine environment; and shear wave data as an aid in defining seafloor engineering properties, depositional environments, lithologic variability, and elastic rock properties. Additional discussions will be held on pattern recognition, which is the automated detection, classification, and ordering of pseudo-random data. This data may be used for geologic and bathymetric charting and for structural and sedimentological analyses.

Prospective authors are requested to submit an abstract, a biographical sketch, and a statement of audiovisual requirements to J. Alan Ballard, Chairman, SEG/USN Technical Program, NORDA, NSTL Station, MS 39529 (telephone: 601-680-4760). Abstract deadline is January 8.

Participants should preregister with Myron Webb, Department of Conferences, University of Southern Mississippi, Long Beach, MS 39560 (telephone: 601-888-3054). The registration fee is $25. Lodging reservations should be made by March 10 through the Diamondhead reservations office (telephone 800-647-9550, 601-255-1421 in Mississippi). ⊠

Groundwater Conference

The 11th Rocky Mountain Groundwater conference will be held April 14–16, 1982, in Salt Lake City, Utah. Topics to be covered at the meeting include groundwater contamination, groundwater monitoring, and water well technology. In addition, a field trip to Salt Lake Valley is planned.

Send titles of proposed papers and requests for additional information to Joseph St Gates, U.S. Geological Survey, W. R.D., 1745 West 17th South St., Salt Lake City, UT 84104 (telephone: 801-524-5654). Deadline for paper titles is January 15. ⊠

News

Luxuriant Life on the Galápagos Seafloor

Marine life found unexpectedly in 1977 in the vicinity of hydrothermal vents along the Galápagos Rift has proven to be of considerable interest because of newly discovered growth mechanisms. Among the life forms observed were giant tube worms, clams, mussels, and plantlike animals. If the sizes alone were beyond belief, the hostility of the living environment—noxious, hydrogen sulfide-rich warm pockets—appeared bizarre. Even though life at depths of 2.5 km on the seafloor is known normally to be sparse in comparison with shallow-water biological systems, the heated water pockets seem to account for the localized contradictions. What was difficult to explain was the toxic environment and the apparent lack of nutrients. Furthermore, the tube worms had no mouths, not even digestive systems. Recent reports in *Science* (November 20, 1981), and by the Smithsonian Institution (Research Reports), describe findings on bivalves studied at the hydrothermal vents and tube worms returned to the laboratory by the U.S. Navy research submersible *Alvin*. The growth rates are among the highest known for deep-sea life. The way the deep seafloor marine life are understood to 'eat' (absorb nutrients would be a better description) involves mechanisms never observed before that breakdown hydrogen sulfide with bacteria.

The giant-size marine life along the Galápagos rift exist in pockets next to hydrothermal vents. Instead of the cold temperatures of the surrounding seafloor (close to 2°C), these pockets are warm (10°–27°C). According to the Smithsonian Institution, several dozen worms (a 1.5-m-long worm from the rift, *Riftia pachyptila* Jones, was named after Smithsonian worm expert M. L. Jones—*Science*, July 17, 1981), were collected by the *Alvin* crew from colorfully named warm pockets along the rift such as the 'Dandelions,' the 'Garden of Eden,' and the 'Rose Garden.' Research done by several international groups determined that there was little or no organic material in the surrounding mud from which the worms were extracted; that left only one possibility—the worms somehow could live, and thrive, on a byproduct of hydrogen sulfide. Close examination of the long body trunk portions of the worms revealed tiny crystalline grains of pure sulfur, evidence of some sort of mechanism that was capable of breaking down H_2S, the sulfur being left as a precipitate. As a result of studies of the worms (several results on *Riftia pachyptila* Jones are reported in the July 17, 1981, issue of *Science*, pp 333–346), it was deduced that the mode of taking nutrition used by the worms involves a detoxification step that reduced the sulfide chemically. There are complex steps of catalysis and synthesis of carbohydrates and proteins by enzymes in bacteria that live in the worms. The carbohydrate and protein nutrients thus produced are taken up by the muscle tissue of the worms, the result of an ideal symbiosis.

The growth rates of the rift seafloor animals seem to reflect the high efficiency of the automorphic nutrition process. Mussels that have been studied from the rift have growth rates of 1 cm per year, considered among the highest for deep-sea organisms, and clams are observed to grow at 5 times that rate.—*PMB* ⊠

EOS
TRANSACTIONS, AMERICAN GEOPHYSICAL UNION

The Weekly Newspaper of Geophysics

Send double-spaced manuscripts (four copies) to *Eos*, AGU, 2000 Florida Avenue, N.W., Washington, D.C. 20009, or send them directly to one of the associate editors with a copy to the above address.

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Cover. Amphibolite-grade rocks of the Lower Paleozoic Shoo Fly Complex in Tuolumne and Mariposa counties, California, comprise the most pervasively deformed basement rocks of the west central Sierra Nevada. In this oblique photo of a typical Shoo Fly psammite, F_2 isoclinal folds deform a penetrative mylonitic foliation (S_1) which is developed along axial planar to intrafolial isoclines. Near the top of the photo note the eyefolds caused by superposition of folding episodes. Spaced ductile shear zones (S_3) are related to a third phase of folding not shown here. The third structures are isoclinal and sheath folds with significant shearing along S_3. The third structures progressively grade into a blastomylonitic foliation near the Calaveras-Shoo Fly Thrust—a probably deep-seated, cryptic suture. In the vicinity of the thrust, older structures are metamorphically overprinted and obliterated by the third-phase mylonites. While away from the thrust (as shown here) the older metamorphic fabrics, which are themselves often mylonitic, predominate. Brittle conjugate cleavages are a product of Mesozoic orogenesis. (Photo by Charles Merguerian of Lamont-Doherty Geological Observatory and Hofstra University.)

Magnetospheric Cleft

The magnetospheric cleft is an opening between the earth's magnetic field and the interplanetary field associated with the magnetic poles. Charged particles entering the earth's upper atmosphere cause the airglow or aurora which occurs in the polar regions. At this time of year, as the sun approaches winter solstice and is below the horizon in northern Canada, atmospheric conditions can be studied on the 'sunside' of the earth as they appear in the dark from the ground. The cleft offers a unique opportunity to study particle acceleration mechanisms in a regime that is less structured in space and time, as opposed to the highly dynamic nightside auroral region, yet is equally interesting and physically rewarding.

The National Aeronautics and Space Administration and the National Research Council (NRC) of Canada will hold a cooperative, sounding rocket program in the Northwest Territories of Canada to study the dynamics of the cleft. Five large rockets carrying some 30 experiments will be launched into the prenoon, noon, and postnoon magnetospheric cleft region this fall. Ground-based instrumentation stations were installed this past summer at Cape Parry and Sachs Harbor, N.W.T., as well as additional launch support and accommodation facilities at Cape Parry.

There are practical as well as scientific reasons for this study because what happens in this region can cause problems ranging from communications disruptions to pipeline corrosion and, in ways not yet fully understood, can influence long-term weather patterns. The primary goal of the Cleft Energetics, Transport and Ultraviolet Radiation (CENTAUR) Project will be a comparison of mechanisms responsible for the production of Birkeland currents—great sheet currents of electricity that run into and out of the ionosphere around the auroral ovals—and the associated energization of charged particles in the pre- and postnoon magnetospheric cleft. In particular, the anticipated difference in the direction of the electric field downward on the morningside and upward on the eveningside implies different mechanisms involving different charge carriers. Data will be acquired by an assortment of ground instrumentation and sounding rocket payloads instrumented with sensitive scientific experiments. Some anticipated results are *(a)* determination of the mechanism(s) responsible for particle acceleration in the cleft; *(b)* delineation of differences or similarities between pre- and postnoon acceleration processes (i. e., how can morning electron arcs be produced when the overall parallel electric field has the wrong sign); *(c)* verification of the presence of tangential (shear) discontinuities in the cleft ion flow (region of no electric field) and the scale size of the null electric field (zero flow) (is it as small as the local ion gyroradius?); *(d)* determination of the spatial relationship between ion shear flows, field-aligned currents, particle acceleration (inverted V's), dayside auroral arcs, and associated waves; *(e)* observation and analysis of plasma instabilities generated by currents. Special interest will be centered on the field-aligned currents by which the ion cyclotron instability is known to be generated. Also it is possible that the reversal in plasma flow across the current sheet can generate the Kelvin-Helmholtz instability.—*PMB* (source NASA) ⊠

Computers More Capable, Less Costly

During the past four decades of computer development, diminishing size of the integrated circuit has led to exponential increases in the capability of semiconductor chips and a steady decrease in the costs of computing. The size reduction of circuit components has resulted in a series of problems of an ultimate limit decrease and in the introduction of natural smallness barriers involving quantum effects. Techniques for fabricating microminiature chips are size limited for similar reasons. There is a marked increase in research being done in submicrometer dimension circuitry. Recently, Cornell University dedicated a new multimillion dollar building to be headquarters for the National Research and Resource Facility for Submicron Structures.

The increase in reliability of miniaturized integrated circuits in computer application over the past four decades is excelled only by their increased capabilities. Figure 1 shows a plot of the semiconductor chip capability in computer-circuit function per chip versus time in years. Significant benchmarks in this logarithmic increase are commercial development of the transistor itself in 1957, the integrated circuit in the early 1960's, the one-chip calculator in 1970, and the exponential random access memory circuits during the last decade.

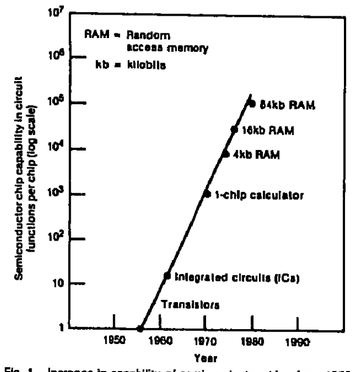
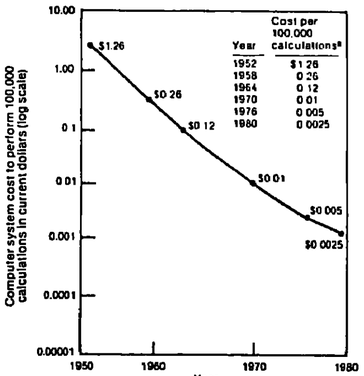


Fig. 1. Increase in capability of semiconductor chips from 1956–1980.

In the same time period, costs of the circuits and devices that utilize them are dropping rapidly. According to a recent report by the Congressional Office of Technology Assessment (OTA) (Computer-Based National Information Systems, OTA, 1981), the costs of storing and processing are so low now that the effects on society are 'as dramatic as those caused by the invention of the printing press.' The drop in average computer system costs per 100,000 calculations in the time span 1952–1980 is shown in Figure 2. The cost per 100,000 calculations in current dollars is plotted against time. These costs went down from $1.26 in 1952 to $0.0025 in 1980 (per 100,000 calculations).



*Cost per 100,000 calculations is based on data for the following IBM computer systems (with year in parentheses): 701 (1952); 7090 (1958); 360/50 (1964); 370/155 (1970); 3033 (1976); 4300 (1980).

Fig. 2. Drop in average computer system cost per 100,000 calculations from 1952–1980.

The limits to continued lowering of costs and increases in miniaturized circuit capability are rapidly approaching. According to a brief report describing the new Cornell Submicron Facility (*Industrial Research and Development*, November 1981), as the circuits get smaller '. . . familiar rules [of physics and chemistry] no longer apply, owing to quantum mechanical effects.' A major project in the research of microcircuits is ultra-small-scale electron beam etching of semiconductor chips. It is now possible to etch lines with widths less than 15 Å on a circuit substrate. Light-ion beams (hydrogen ions) are being used for the same purpose, but to avoid electron scattering effects (the 'small proximity effect'). High resolution in etching and imaging circuits onto substrates is being advanced.—*PMB* ⊠

Earth Sciences Grants

As part of a 4-year, $5-million program by the Atlantic Richfield Foundation, 14 departments at 10 universities will receive grants to support doctoral students and junior faculty in geology and geophysics. The Atlantic Richfield Foundation will provide a total of 40 grants of $125,000 each to specific departments at 30 universities (10 universities will receive two grants each).

For each grant, $25,000 will be applied annually for 4 years for fellowship support of outstanding doctoral students selected by the department receiving the grant. The fellowships are intended to encourage greater interest in teaching careers. The other $25,000 of the grant will be for the support of junior faculty. The funds are to be supplied at the discretion of the receiving department and are primarily for salary supplements and summer stipends or for new equipment and laboratory expenses.

The universities and departments that will receive the grants, according to the Atlantic Richfield Company, are the Colorado School of Mines, geology and geophysical engineering departments; Texas A&M University, geosciences department; University of Southern California, geological sciences department; University of Colorado, geology department; Columbia University, geological sciences department; Louisiana State University, geology department; University of Minnesota, geology and geophysics departments; University of Oklahoma, geology and geophysics departments; University of Wisconsin, geology and geophysics departments; and Yale University, geology and geophysics departments.

Nation's Water Picture Better But Southeast Still Dry

The flow of the nation's 'Big Five' rivers, representing stream runoff from about half of the conterminous United States, increased during November and was 13% above normal for the month, according to the U.S. Geological Survey. USGS scientists said flow of these rivers—the Mississippi, St. Lawrence, Ohio, Columbia, and Missouri—increased from 483 billion gallons per day (bgd) during October, a rate which was 2% above normal for the month, to 553 bgd during November. Because of the large area draining into the Big Five, their combined flow provides a quick, useful check on the pulse of the nation's water resources. The Big Five flow has been above average for the last 6 months.

As a further indication of the generally healthy water situation, the USGS reports that over 70% of the 167 key index gaging stations across the country reported normal to above-normal streamflow during November. Conditions in the Southeast and scattered parts of the central and western states, however, remain well below normal.

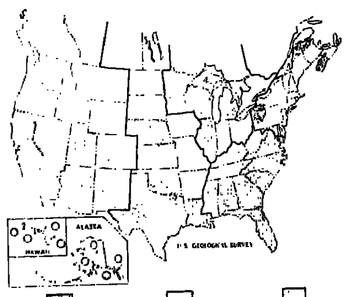
Working in cooperation with federal, state, and local officials, the USGS compiled the following highlights of water resources conditions across the country in November:

- *Big Five.* Individual flows of the Big Five for November: Mississippi River near Vicksburg, Miss., 229 bgd, 17% above normal and 28% above October's flow; St. Lawrence River near Massena, N.Y., 192 bgd, 20% above normal, but 1% below last month; Columbia River at The Dalles, Ore., 56 bgd, 1% below normal, but 2% above October; Missouri River at Hermann, Mo., 39 bgd, 10% above normal and 14% above last month; and the Ohio River at Louisville, Ky., 37 bgd, 8% below normal, but 64% above October.
- *Southeast.* Two key streams set new record lows as the dry spell in the Southeast continued. Twenty-six of the 32 key index stations in the eight coastal states from Virginia south to Florida and west to Louisiana reported below-normal streamflow during November. In addition, parts of eastern Tennessee and Kentucky also reported below-normal flows.

As in October, monthly flows were below normal at all six of the index stations in Florida. In Georgia, three of the state's four index stations reported below-normal flows.

Surface- and groundwater levels were below normal in Virginia and the Carolinas. The usual seasonal flow pattern in Virginia is for streamflow to take an upturn during November, but, in contrast to the usual trend, flows on all four of the state's key streams declined and were below normal.

Streamflow during November



Above normal (within the highest 25 percent of record for this month) | In normal range | Below normal (within the lowest 25 percent of record for this month)

Groundwater levels in North Carolina remained 0.5 to 2.5 feet below the long-term average.

- *Northeast.* Streamflow was in the normal range throughout most of the Northeast, with 18 of 25 key index stations from New England to Maryland reporting normal monthly flows. In contrast, Long Island, central Maryland, and most of New Jersey reported below-normal flows.

Groundwater levels generally rose in New England where 50 of the 58 key index wells in Massachusetts, Vermont, New Hampshire, and Rhode Island reported levels above those measured last month. The rise brought half of the key wells up to levels at or above the long-term average for November. Groundwater levels increased throughout upstate New York and in most of Connecticut. In contrast, three key wells in Maryland set record lows for November.

- *Middle Atlantic.* Freshwater inflow to the Chesapeake Bay, representing stream runoff from a 65,000 square-mile area of the Middle Atlantic states from New York to Virginia, averaged 32 bgd, 9% below the average November inflow of 35 bgd. Inflow to the Bay has averaged below normal for most of the last 18 months.
- *Great Lakes and Midwest.* Streamflow and groundwater levels were in the normal range in most of the Great Lakes region and Midwest, although flows were below normal and several key wells fell to record lows in parts of the Midwest. For example, index stations in Nebraska, Iowa, and Kansas indicated below-normal streamflows, and observation wells in Kansas, Arkansas, and North Dakota established new lows.
- *West.* Flow conditions were in the normal range in most western states, except for Montana and parts of Arizona and New Mexico, where streamflow averaged below normal, and California and Utah, where streamflow averaged above normal. Three wells tapping the basalt aquifer (water-bearing rock formation) beneath the Snake River Plain in Idaho reached new month-end lows. (Photo credit: U.S. Geological Survey, Department of the Interior.)

Forum

Meteorological Rocket Network Archives

The Meteorological Rocket Network (MRN) has provided synoptic observation of middle atmospheric (25–60 km) wind and temperature structure for more than two decades since its initiation in 1959. More than 35,000 small meteorological rockets have been deployed into the stratospheric circulation (SC) from more than 30 stations scattered over the earth, with current accumulation rates of roughly 1000 soundings per year. Archives of this MRN development have been assembled at the University of Texas at El Paso, and this permanent repository for past and future MRN data and artifacts will be dedicated on February 2, 1982. All atmospheric scientists are welcome to contribute to, take part in dedication of, and make use of all information contained in these archives.

Missile range meteorologists implemented small meteorological rocket development during the 1950's to satisfy requirements for mesoscale atmospheric structure data during rocket tests. They cooperated in this venture to assure efficiency, and through this cooperation they opened a new world of dynamical structure unknown to previous generations. Efforts to maximize returns from meteorological rocket sampling through synoptic coordination have revolutionized knowledge of SC structure at the gross end of the turbulent spectrum. At the same time, the necessity of developing small and inexpensive rocket observational systems has produced sensitivities which reveal prolific small-scale turbulence and a viscous nature of the upper atmosphere. Notions that flows are laminar in the upper atmosphere and free of highly significant eddy transport processes, and/or that any features observed there have certainly propagated upward are eliminated from rational scientific analysis by these MRN results.

MRN data have doubled the synoptically observed atmospheric volume and have revealed detailed knowledge of (*a*) interhemispheric flows between SC monsoonal circulations during 'winter storm periods,' which serve to unify and mix the global upper atmosphere; (*b*) explosive warming events in polar winter stratopause regions with wind and temperature variations of several hundred knots and as much as 100°C over a few days time; (*c*) diurnal tidal circulations with tens of knots amplitude around a roughly 15°C stratopause heat wave which serve to stir mesospheric and dynaspheric regions (50–100 km); (*d*) a highly turbulent and viscous upper atmosphere.

These MRN results make it impossible to adequately model environmental support for space age technology without current knowledge of all aspects of what is obviously a unified atmospheric dynamical system.

A primary message of MRN synoptic SC investigation is that the upper atmosphere is not the static place that had been assumed. In reality, the upper atmosphere is a highly turbulent and variable region. This dynamic nature emerges from a reduced ambient density medium which serves to amplify traveling perturbations that are commonly damped out of most lower atmospheric observations as inconsequential. Viscous inducing processes that accompany dissipation of these waves communicate the underlying structure of the earth's surface and lower atmosphere to the rarefied upper atmosphere and reveal the total unified atmospheric structure. This inhomogeneous source of energy input is incorporated into local dynamical structures that span the entire turbulent spectral range, from synoptic events of hemispheric dimensions to cascading dissipation of smaller and smaller internal waves into thermal structures.

Failure of models based on static assumptions to yield realistic models of special features of upper-atmospheric structure, such as noctilucent cloud formations, sudden warmings, dynamo current motivation, airglow, and auroral activity, as well as general ionospheric structure, is easily understood in the face of this intense turbulent activity. Chemical and electrical structures of the chemisphere and ionosphere are highly dependent on eddy transport structures, as is the water vapor structure required to support noctilucent cloud formation in mesopause regions. Interactions between the earth's neutral atmosphere and the near-solar environment are similarly dependent on viscosity produced by much larger eddy transport coefficients, which are now known to dominate upper atmospheric regions.

The Meteorological Rocket Network Archives (MRNA) consist of a complete set of MRN data reports (166 volumes), books that deal with MRN development and data analysis, scientific reports, manuals, organizational and administrative reports, and examples of rocket and sensor hardware. A history of the MRN effort has been prepared to summarize this twofold expansion of synoptic meteorology and to provide a ready reference (more than 300 entries) for all scientists of the contents of the MRNA. All atmospheric scientists are invited to acquaint themselves with these archives so that they can make full use of MRN data to discern the unified atmospheric structure which is now known to exist. Inquiries about accumulation, dedication, and use of the MRNA should be addressed to Willis L. Webb, Schellenger Research Laboratory, University of Texas at El Paso, El Paso, Texas 79968 (telephone: 915-747-5552).

New Publications

Estuarine Hydrography and Sedimentation

K. R. Dyer (Ed.), Cambridge University Press, New York, ix + 230 pp., 1979, $39.50.

Reviewed by James P. Bennett

An extremely wide variety of disciplines can often become involved in even the simplest estuarine-water-quality study. The complexity of processes combined with cumbersome logistics and the tremendous expense of conducting estuarine studies make it imperative that all possible influencing factors be anticipated in data-collection program design and execution. Dyer's stated purpose is to provide estuarine researchers and students with 'advice on techniques of analysis and ways of interpreting data which are rather foreign to them, even though they are within the general area of estuarine studies.' The book is, however, not intended to be a cookbook but be a source in which techniques are outlined together for comparison with references to other publications for details. The book is a compilation of contributions, and a few of the authors are less successful than others in achieving Dyer's objectives; but, by and large, it is a worthwhile addition to estuarine research literature.

The first chapter introduces the physical and hydrodynamic framework. It has an excellent section describing the classification of estuaries with respect to circulation types and another section that emphasizes the recently appreciated fact that classical circulations are frequently interrupted by flow patterns induced by weather. The chapter also discusses the interactions between sediment and circulation that produce the turbidity maximum and increase the trap efficiency of estuarine systems. The chapter has an excellent bibliography as well.

Tidal measurement is the topic of the second chapter. It emphasizes the importance of referencing tide gages to local datum and gives troubleshooting hints and check procedures to ensure reliable operation of automatic float gages. It does not, however, include the techniques of (1) using a measuring tape instead of a wire to connect the pen and float; (2) using a portable, clear plastic stilling well to read the staff gage; or (3) obtaining common datum for several gages on the same estuary. Neither does the section discuss the importance of precise timing of tide records (or modern quartz timers) in running and calibrating digital hydrodynamic models. Also, few of the references in chapter 2 would be readily available to U.S. readers.

Chapter 3 outlines hydrographic surveys, which includes position fixing and depth sounding, whereas chapter 4 covers side-scan sonar and reflection seismic profiling. With the exception of the optical position fixing techniques, the procedures discussed in these chapters are 'equipment-dependent,' so manufacturer's operating manuals should be carefully consulted in designing sampling programs. Reading side-scan and seismic profiling charts is still very much of an art, so expert help should always be obtained in interpreting these records.

Estuarine bottom sediments provide homes and food sources for many organisms. Sediments entrap many pollutant materials and are important in recycling nutrients. Their size composition reflects local water dynamics, their mineralogy reflects source material, and the combination of these two characteristics may be indicative of contrast between prevailing modern and prehistorical transport processes. With the exception that it omits discussing the Ponar Grab, chapter 5 is an excellent review of the principal methods of obtaining sediment samples, the analytical techniques used to determine the particle size distributions of these samples, and how these analyses may be interpreted to provide information about the environment from which they were collected. This chapter also has a complete and relatively up-to-date bibliography.

Circulation patterns in most estuaries are such that these systems are essentially perfect traps for suspended sediment. Understanding sediment transport is thus the key to understanding shoaling, pollutant dynamics, and many other aspects of estuarine behavior. Chapter 6 deals with determination of suspended material concentration, the properties of this material, and the interpretation of the results of these analyses. The chapter contains a worthwhile discussion of the difficulty of obtaining representative values for in situ particle density, size distributions, and fall velocities. It also provides a concise review of the literature on the computation of sediment fluxes and the processes associated with turbidity maxima in estuaries with different types of circulation.

Almost every estuarine study includes some form of measurement of current velocity, water temperature, and salinity. Chapter 7 discusses the spatial and temporal variability of these parameters in relation to rational design of a sampling program. It discusses actual collection of these data and presents a computer program that provides a standardized analysis procedure. Following this, net discharge and flux computations are defined, and a numerical example is given to illustrate the importance of using the proper definition to calculate tidal-cycle average values.

The book provides a good introduction to estuarine hydrography and sedimentation. It emphasizes processes, outlines techniques, and points to pitfalls without dwelling on detailed procedures. With one or two exceptions, the references listed are adequate for readers requiring more detail in particular study areas. The book is generally successful in achieving the editor's purposes, and this reviewer is anticipating the appearance of the promised companion volumes on estuarine chemistry and estuarine biology.

James P. Bennett is with the U.S. Geological Survey, Reston, Va.

The Ore Minerals and Their Intergrowths, 2nd ed.

Vol. 35, International Series in Earth Sciences, 2 vols., P. Ramdohr, Pergamon, New York, xxxvii + 1207 pp., 1980, $200.00.

Reviewed by Paul B. Barton, Jr.

Paul Ramdohr, professor of mineralogy, Heidelberg University, Heidelberg, Federal Republic of Germany, is a revered institution among students of ore deposits. For half a century he has been the leading authority on ore minerals and their textural interpretation. His third German (and first English) edition (1969) of this title is a standard reference. His descriptive mineralogical work and presentation of a wide variety of ore textures are without peer.

The author and publisher are commended and thanked by this monolinguistic reviewer for publishing this book in English editions, in addition to those in German. The sentence structure is often Teutonic, but in only a few places was this reviewer left mystified (e.g., p. xix, lines 7–11; and the last sentence on page 13). In the course of review, my copy of volume 1 logged several thousand miles in my briefcase; the page binding is now showing signs of wear, and I am concerned for its longevity as a shelf reference in the microscope laboratory.

The new edition notes more than 400 ore and gangue mineral species, a quarter of them new since the previous edition. It is for the mineral descriptions that one seeks out *The Ore Minerals and Their Intergrowths*, and in this area Ramdohr has kept up rather well. However, most of the new minerals are very tersely noted, and the beautiful photographs so characteristic of Ramdohr's work are seldom given for the newer minerals.

The book begins with 78 pages of genetic systematics dealing with the processes that produce ore minerals and continues with about 200 pages on ore textures and their general interpretation. The most valuable and voluminous part of the book is the systematic description of the ore minerals, which is nicely supplemented by many black-and-white photographs of the minerals and their textures. More than 800 photographs provide a remarkable catalog of mineral textures and show an amazing perfection in low-relief surface preparation. New photographs constitute about 15% of the total. Ramdohr places great emphasis on oil-immersion optics, even for low magnification; thus he achieves a contrast between minerals that is considerably accentuated beyond the images that those of us accustomed to dry optics may remember. The second English edition devotes 85 pages to 'Elements and Intermetallic Compounds,' 47 pages to 'Alloy-Like Compounds and Tellurides,' 452 pages to 'Common Sulfides and "Sulfosalts",' 108 pages to 'Oxidic Ore Minerals,' and 123 pages to 'Gangue Minerals and Non-Opaque Oxide Ore Minerals.' A 20-page table of 'New Reflectivity Values' is inserted in a pocket at the back of the first volume; it is the most up-to-date feature, as it cites 1976 and 1977 references. A 37-page locality index, a 1135-entry bibliography, a 1-page alphabetical subject index (far too brief), and a 6-page mineral index are included. Ramdohr is particularly thorough in his treatment of the iron-titanium oxides and reduced uranium minerals, and the overall coverage is very comprehensive. The variety is tremendous, and ideas for additional work abound. In contrast, transmitted light study of the transparent ore minerals, an area of rapidly growing importance (for example, see McLimans, Barnes, and Ohmoto, *Econ. Geol.*, p. 351, 1980, or Barton, *Mining Geology, Japan*, p. 293, 1978), receives very little discussion.

The editing and technical reviewing could have been much more thorough. The scales of four photographs were changed by about 50% from the first to the second English edition. In each photograph the statement about magnification was that of the earlier version. The photographs in the new edition are generally, but by no means universally, superior to the older edition, being of higher contrast and sometimes in sharper focus. Unfortunately, most of the captions come directly from the earlier edition, and all too often one finds that 'gray' may in fact be black. Some photographs have gained detail, but a few have lost it. Some downright errors appear, such as that on page 248, where the compressibility of the host crystal is blamed for the necessity for pressure corrections for some fluid-inclusion thermometry; the cinnabar-metacinnabar transition is listed as monotropic, despite clear evidence to the contrary by Dickson and Tunell in 1959 (*Am. Mineral.*, p. 471).

Because no author index is given, the reviewer may have overlooked a few citations, but overall the lack of modern references is surprising, and even where modern references are given in the bibliography, they are all too often ignored in the text. The second English edition contains about 1135 references (the dust jacket claims only 800!), but they represent little of the modern literature. The most recent references are two for 1977, the most recent decile begins in 1971, and the median date of citation is 1956—a full quarter century ago! This reviewer grants that all too often valuable older studies are neglected just because they are not 'modern,' but science is a dynamic thing, and reverence for history is only a part of knowledge. How, for example, can one justify even a half-page review of fluid inclusions by citing H. C. Sorby and W. H. Newhouse without even mentioning Edwin Roedder? Why should a list of 18 sources of information on geological thermometers give no references more recent than 1964? Why would a discussion of 'transformed textures,' including annealing and exsolution, not cite Richard Stanton or even contain the terms 'spinode' or 'coherent exsolution'? Why, in view of numerous definitive geochemical studies to the contrary by Julian Hemley and others, should the author state that 'hot alkaline waters' are the main agents of wallrock alteration? Why is there a 12-page discussion of 'colloidal' textures and no mention of Edwin Roedder's penetrating 1968 criticism (*Econ. Geol.*, p. 451) of so-called colloidal textures? Not even passing mention is made of the widely available 1974 Mineralogical Society of America Short Course Notes on Sulfide Mineralogy. The treatment of the Fe-S and Cu-S systems is far out of date for a 1980 publication, and Richard Yund and Gunnar Kullerud's 1966 publication (*J. Petrol.*, p. 454) on the Cu-Fe-S system is cited as though it were still in progress. Livingstonite ($HgSb_4S_8$) was shown by James Craig in 1970 (*Am. Mineral.*, p. 919) to contain that extra sulfur atom, yet the wrong formula is given. The discussions of the silver-gold tellurides bemoan the lack of an understanding of the phase relations but they ignore the careful studies of Louis Cabri (*Econ. Geol.*, p. 1569, 1965) and William Kelly and E. N. Goddard (*Geol. Soc. Am. Mem.*, p. 109, 1969). Many more such examples can be cited in which recent work has been ignored.

The distribution of publication dates in the list of references suggests either that the book is far out of date or that it chronicles the decay and demise of a particular corner of science; in fact, both are true. By the late 1940's, observation of ores had outdistanced theory, and the standard interpretations of the day gradually became recognized as unsatisfactory. Textural interpretation was viewed with suspicion and was performed perfunctorily. The practitioners of ore petrography of the 50's grew to rely on reflectivity and microhardness (and in the '60's on the microprobe); chemography was all too often substituted for careful textural interpretation. We are now seeing a renaissance of textural interpretations based on a steadily improving thermodynamic base, a rapidly growing reservoir of kinetic theory and data, and more thoughtful work with the microscope and microprobe. Ramdohr represents the 'old school' very creditably; in many respects, he helped pioneer the new wave without becoming part of it himself. It is well for modern workers to appreciate and benefit from the large body of older work so extensively presented by Ramdohr.

We have in the second English edition of *The Ore Minerals and Their Intergrowths* a book that was very well written in the mid-1960's and superficially revised in the late '70's to the extent of adding newly discovered minerals and a few excellent additional photographs of older ones. This is not a modern textbook for ore petrology; it is, however, by far the best compilation of superb ore photographs available. A first-rate microscopy laboratory needs a copy of Ramdohr, but after comparing both editions (and considering the high price of the second), this reviewer sees few compelling reasons to replace the older edition with the recent one.

Paul B. Barton, Jr., is with the U.S. Geological Survey in Reston, Va.

Classified

EOS offers classified space for Positions Available, Positions Wanted, and Services, Supplies, Courses, and Announcements. There are no discounts or commissions on classified ads. Any type that is not publisher's choice is charged for at display rates. EOS is published weekly on Tuesday. Ads must be received in writing on Monday-1 week prior to the date of the issue required.

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POSITIONS AVAILABLE

Surficial Geology/Groundwater. Utah State University. Tenure track position starting spring quarter of 1982 or fall quarter of 1982. Ph.D. required. Rank and salary negotiable. Surficial geology with emphasis on geologic field studies and ground water with attention to both geologic and geohydrologic aspects. Emphasis on the arid West. Closing date November 30, 1981. USU is an affirmative action equal opportunity employer. Department of Geology (07), Utah State University, Logan, Utah 84322.

Seismologist/University of Utah. Search extended: the University of Utah is expanding its geophysics program in the Department of Geology and Geophysics by adding a tenure track faculty member in seismology at the assistant to associate professor level. Applicants with backgrounds and specialties in seismic reflection, seismic imaging, and theoretical seismology will be given preference. The individual will be expected to teach undergraduate and graduate courses, and to pursue an active research program with graduate students. The department has modern teaching and research programs in geology and geophysics, and has close associations with the numerical analysis and data processing groups in computer science, electrical engineering and mathematics. The geophysics component of the department has strong research and teaching programs in seismology, electrical and electromagnetic methods, thermal properties of the earth, and potential fields. Current research in seismology includes: seismological and earthquake research utilizing a new PDP 11/70 computer with plotter and terminals; monitoring of the intermountain seismic belt by a 55 station telemetered network utilizing a new on-line PDP 11/34 computer; major experiments in seismic refraction profiling, investigations of seismic propagation from synthetic seismograms, application of inverse theory to seismology, seismic properties of volcanic systems and allied research in tectonophysics. The closing date for applications is December 31, 1981. A Ph.D. is required for this position. Applicants should submit a vita, transcripts, a letter describing his/her research and teaching goals, and names of five persons for reference to William P. Nash, Chairman, Department of Geology and Geophysics, University of Utah, Salt Lake City, Utah 84112.

University of Utah is an equal opportunity/affirmative action employer.

Research Associate in Planetary Geology at Brown University, Providence, Rhode Island. Experience is geologic/geomorphic analysis of planetary images, study of surface geologic processes, computerized image processing, and/or quantitative geomorphology is desirable. Deadline for applications is May 31, 1982. Submit resume, names and addresses of three references to Dr. James Head, Box 1846, Brown University, Providence, RI 02912.

Brown University is an equal opportunity-affirmative action employer.

Research Associate/Electron Microprobe. The Electron Microscopy Center at Texas A&M University invites application for the position of Electron Microprobe Specialist. Applicants should possess a working knowledge of WDS and EDS spectrometers and accompanying computer and software programs and preferably have had experience in the Geological Sciences.

The primary duties of the position are to oversee and maintain (with the aid of service contracts) the electron microprobe and ancillary equipment and to assist in teaching graduate course laboratories dealing specifically with electron microprobe analysis. Salary will be up to $25,000/12 months.

Applicant should send supporting data and letters of recommendation to:

Dr. F. L. Thurston
Texas A&M University
Biological Sciences Building
College Station, Texas 77843

Texas A&M is an equal opportunity/affirmative action employer.

Crustal Geophysics/Tectonophysics or Sedimentology. The Department of Geology at the University of Kansas is seeking applicants at the assistant professor level for a potential additional tenure track position that will begin in August, 1982 or January, 1983. The appointment will be made in either crustal geophysics, tectonophysics, structural geology, or in sedimentology. The area in which the appointment will be made will depend upon the qualifications of the applicant and departmental needs. Duties include teaching in our introductory, undergraduate major, and graduate courses; advising students; supervising graduate student theses and dissertations; conducting original research; and providing service through administrative and professional activities. Applicants must have Ph.D. in hand or expect to complete it by the end of the first year of employment at the University. Minimum salary at the assistant professor level will be $23,000, if the position is authorized.

Crustal Geophysics, Tectonophysics or Structural Geology. We will consider applicants from all fields of geophysics and structural geology who are interested in applying their expertise to understanding the structure and evolution of the earth's crust and who will complement the five existing geophysics faculty of the Department and the Kansas Geological Survey. The successful applicant will be expected to cooperate with current faculty in offering courses at the undergraduate and graduate level that cover geophysics, tectonics, or structural geology.

Sedimentology. We will consider applicants in any branch of sedimentology, but those with interests in studying carbonate rocks, diagenesis and sedimentary geochemistry, or the relationships of sedimentation and tectonics are preferred. The applicant will be expected to cooperate with present faculty in offering courses at the undergraduate and graduate levels that cover all aspects of the study of sedimentary rocks.

Persons who have responded to earlier advertisements this year for sedimentology and structural geology need not re-apply, but will be automatically considered. In the event top candidates are about equally qualified, preference will be given to applicants whose areas of interests will complement those of the other faculty or who will participate in the department's summer field geology teaching program.

Priority will be given to applicants whose files are complete by February 1, 1982. Applicants should send a letter of application, a resume (including publication list), transcripts of all college level work, and names of three references to:

Ernest E. Angino
Department of Geology
University of Kansas
Lawrence, Kansas 66045
Phone: (913) 864-3771

The letter of application should include a statement of current and planned research interests and of courses that the applicant feels qualified to teach.

An equal opportunity affirmative action employer. Applications are sought from all qualified people regardless of race, religion, color, sex, disability, veteran status, national origin, age, or ancestry.

Structural Geologist/University of Wyoming. The University of Wyoming, Department of Geology and Geophysics seeks applicants for a tenure track appointment in structural geology expected to be available beginning fall semester 1982 or earlier. Duties will include teaching of undergraduate and graduate courses in structural geology, supervising MS and PhD theses, and research in structural geology. Appointment at assistant professor level is preferred, but applicants requesting appointment at higher rank will be considered. Salary open. Applicants must have PhD degree and be versed in quantitative theory as well as field applications or modern structural geology and regional tectonics.

Applicants should provide, by January 1, 1982, a resume, three letters of reference, and a letter of application including a statement of current research interests and courses which the applicant feels qualified to teach. Applications should be sent to

Dr. Robert S. Houston, Head
Department of Geology and Geophysics
University of Wyoming
Laramie, Wyoming 82071-3006.

The University of Wyoming is an equal opportunity-affirmative action employer.

POSTDOCTORAL POSITION IN MARINE CHEMISTRY

Woods Hole Oceanographic Institution invites applications for the position of Postdoctoral Investigator. This position is being offered for basic research on the chemistry of the particle flux in the ocean and on the chemistry of sediment-seawater interactions, with particular emphasis on the transport of trace metals and radionuclides. Preference will be given to applicants with training in radiochemistry, trace-element analysis, surface chemistry, or geochemical modeling. Send resume and names of three references to:

Personnel Manager
Box 54P

WOODS HOLE OCEANOGRAPHIC INSTITUTION

Woods Hole, MA 02543
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Hydrology: Tenure Track Position at Assistant or Associate Professor Level. Candidate should be a specialist in some quantitative aspect of hydrology with demonstrated skills in formulating hydrologic models, and a background in transport phenomena. Academic or professional credentials at Ph.D. level required. Starting date negotiable but could be as early as August 1982. Resumes, etc., should be received by March 1, 1982. Interested persons should request job description from: Dr. E. S. Simpson, Chairman, Search Committee, Department of Hydrology and Water Resources, University of Arizona, Tucson, Arizona 85721.

Equal opportunity/affirmative action employer.

Princeton University/Water Resources Program, Department of Civil Engineering. Department of Civil Engineering invites applications for a tenure track, three-year appointment at the assistant professor rank beginning on or before September 1982. Responsibilities include graduate and undergraduate teaching in hydrology and water resources, and participation in research into either hydrological processes associated with infiltration and unsaturated flow or chemical processes and transport in the unsaturated zone. Candidate must have Ph.D. degree with demonstrated teaching ability and scholarship.

Submit resume and references to:

Eric F. Wood, Director
Water Resources Program
Department of Civil Engineering
Princeton University
Princeton, NJ 08544.

Princeton University is an affirmative action/equal opportunity employer.

Positions in Oceanography/VIMS. The Virginia Institute of Marine Science (VIMS)/School of Marine Science invites applications for two state funded, oceanography research and teaching positions at the levels of Senior Marine Scientist. VIMS is a broad-based marine science establishment with a mission to provide sound and timely advice to executive agencies and the legislature and to conduct incisive research programs. The School of Marine Science offers M.A. and Ph.D. programs with a faculty of 66 and 139 graduate students.

HEAD, DEPARTMENT OF GEOLOGICAL OCEANOGRAPHY (#113)

Applicants are sought with research interests in estuarine sedimentary geochemistry, dynamics of cohesive sediment transport, or estuarine and coastal morphodynamics. For further information contact Dr. Robert Byrne (VIMS), 804-642-2111 (Ext. 173)

ESTUARINE AND COASTAL HYDRODYNAMICS (Position #204)

A physical oceanographer with a strong interest in interdisciplinary approaches to complex estuarine and continental shelf problems is desired. For further information contact Dr. Bruce Neilson (VIMS), 804-642-6131 (Ext. 244).

Candidates for both positions should have established research credentials and be dedicated to furthering the research and educational programs of the Institute. Demonstrated ability to generate extramural support is expected. Salary range is $24,972 to $34,107 and faculty rank is commensurate with qualifications.

Applicants should send a comprehensive curriculum vita, reprints, and at least three letters of recommendation by February 1, 1982, stating specific position of interest, to: Employment Manager, Personnel Office, College of Wm & Mary, Williamsburg, VA 23185.

An equal opportunity/affirmative action employer.

Geophysical Fluid Dynamicist/Physical Oceanographer. Applications are solicited for a junior faculty position in ocean physics or dynamics to begin in the academic year 1982–83. Areas of interest to the Department include analytical, numerical and laboratory modeling of physical processes and phenomena in the sea.

Yale University is an equal opportunity/affirmative action employer and encourages women and members of minority groups to compete for this position.

Curriculum vitae, publications, and the names of three or more referees should be sent by 31 December 1981 to: Robert B. Gordon, Chairman, Department of Geology and Geophysics, P.O. Box 6666, New Haven, CT 06511.

Planetary Scientist. SUNY Stony Brook, The Department of Earth & Space Sciences, anticipates that a tenure track faculty position may become available for a PhD Planetary Scientist. Planetary Science within this department spans the range of planetary atmospheres, cosmochemistry, and planetary geophysics. The candidate should have a demonstrated record of accomplishment. The appointee is expected to pursue an active research effort and will be responsible for teaching courses at the undergraduate and graduate level.

Send vitae and names of 3 references to: Dr. Roger Knacke, Dept. of Earth & Space Sciences, SUNY Stony Brook, Stony Brook, NY 11794.

SUNY Stony Brook is an EO/AA employer. AK #229A

Faculty Positions. *Two Faculty Positions in Geology.* Tenure-track positions in geology, assistant professorships. Ph.D. preferred or equivalent experience. Fall 1982.

Petrologist-Mineralogist. Candidate must be able to teach introductory geology, mineralogy, petrology, geochemistry, and optical mineralogy/petrography.

Invertebrate Paleontologist-Soft-Rock Geologist. Candidate must be able to teach courses in invertebrate paleontology, micropaleontology, sedimentation, and historical geology. Additional expertise in recent marine environments highly desirable.

Applicants are expected to do research in their areas of expertise, and to lead students' field trips. Strong teaching and research commitments expected. Submit applications with resume and copies of transcripts, and have three letters of recommendations sent to the Chairperson, Department of Earth & Space Sciences, Indiana University-Purdue University at Fort Wayne, Fort Wayne, Indiana 46805.

Indiana University-Purdue University is an equal opportunity/affirmative action employer.

Iowa State University of Science and Technology/Department of Earth Sciences.

Applications are invited for two tenure track faculty positions. The rank for each is at the assistant or associate professor level, dependent upon qualifications. The successful applicants will be expected to develop strong research and graduate student programs. Teaching duties will include undergraduate and graduate courses in the areas of expertise.

National Science Foundation

The National Science Foundation, in performing its function of support of scientific research, seeks high quality professional staff selected from a broad range of disciplines to carry out the review and evaluation of proposals and to recommend for support those proposals which are most meritorious from the scientific point of view.

Vacancies to be filled in the Division of Atmospheric Sciences are in the following areas of interest:

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- *Oceanography*
- *Paleoclimatology*
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Proposed rotational assignments will be for four Assistant/Associate Program Managers at the EC-12/13/14 level (equivalent to GS-12/13/14), salary range of $28,245 to $51,596 per annum and three Program Managers, EC-14/EP level (equivalent to GS-14/15), salary range of $39,689 to $60,689 per annum (salaries limited by statute to $50,112.50 per annum). These positions are excepted from the competitive civil service and will be for a one- or two-year duration. Candidates should have a Ph.D. or equivalent experience plus six to eight years experience beyond the Ph.D. in the appropriate discipline. Candidates interested in being considered for positions in these areas should forward resumes to the **National Science Foundation, Personnel Administration Branch, Rm. 212, 1800 G St., N.W., Washington, D.C. 20550. Attn: E. Paul Broglio, ATM.**

NSF is an equal opportunity employer.

PLASMA PHYSICIST

The Space Sciences Laboratory of The Aerospace Corporation has an opening available for a Member of the Technical Staff to work in the area of plasma wave research in magnetospheric and ionospheric physics. We have current and future space flight opportunities in this area. Applicants should have demonstrated their ability to develop instrumentation, conduct rocket or spaceflight experiments and to process and analyze data from such experiments. Candidates should have a PhD degree or equivalent in Physics, Geophysics or Space Sciences with a strong background in Plasma Physics.

For immediate consideration, send your resume to: **Margaret Bohnot, Professional Placement, Dept. 00199.**

The Aerospace Corporation

P.O. Box 92957, Los Angeles, California 90009

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Mineral Resources/Economic Geology: One position is in mineral resources/economic geology. An applied field orientation is preferred. Iowa State has established a Mining and Mineral Resources Research Institute and an interdepartmental minor in Mineral Resources in order to support and develop research and education in this area. In addition to the appointment in the Department of Earth Sciences there will be full opportunities to interact with these programs.

Geomorphology: The second position is in the general field of geomorphology. Additional expertise in an area related to geomorphology, such as groundwater, engineering geology or remote sensing is also desired. A person with an applied field orientation is being sought.

Each appointment will be on an academic year basis. Opportunities are available for summer teaching appointments. Salaries will be commensurate with qualifications. Application deadlines for both positions are February 15, 1982; later applications will be accepted if a position is not filled. Positions are both currently available and are expected to be filled no later than fall, 1982. For application information please write to:

Bert E. Nordlie
Department of Earth Sciences
253 Science I
Iowa State University
Ames, Iowa 50011

Iowa State University is an equal opportunity/affirmative action employer.

Atmospheric Scientist. SASC, a leader in the software industry, has immediate requirements for an atmospheric scientist to conduct numerical research in the simulation of optical sensors operating from satellite orbit. Position requires experience with satellite data analyses and active sensors as well as experience on CYBER hardware. Requirements include Ph.D. in Space Physics with a minimum of three years relevant experience. SASC offers excellent company benefits including 3 weeks vacation and dental plan. Salary range $25,000 to $30,000. EOE. Contact Virginia Employment Commission, 222 E. Queen Street, Hampton, VA 23669 (804)722-2841. Attn: Mrs. Dixon.

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EST SERVICES. Scientific Translations From Russian to English. Specializing in Hydrology, Water Resources, and the Earth Sciences: pure research, engineering, construction, systems analysis, mathematical modeling. Experienced, extensive academic training, 15 years professional experience as a geohydrologist, Donald J. Percious, 3219 Camino del Saguaro, Tucson, Arizona 85705 (602) 743-0663.

STUDENT OPPORTUNITIES

Graduate Research Assistantships. Environmental science at the Oregon Graduate Center. Atmospheric and aerosol physics research programs in theoretical modeling of anthropogenic effects on stratospheric ozone and global temperature and in development and utilization of real time instrumentation for sulfur and carbon aerosols. Degree program provides for intensive research experience and maximum student-faculty interaction. $7500 stipend with remission of fees and tuition available to qualified Ph.D. students. Write: Dr. Douglas F. Barofsky, Oregon Graduate Center, 19600 N.W. Walker Road, Beaverton, Oregon 97006.

Exxon Teaching Fellowship at University of Michigan-Geological Sciences. Applications are invited for a three-year fellowship in the PhD program, supported by the Exxon Education Foundation. Annual stipends will be $12,000, $13,500, and $15,000 for the first, second, and third years, respectively, with full waivers for tuition and fees. The successful applicant will be a person who, at the time of the award, intends to pursue a college teaching career, is extremely articulate and has a demonstrably high quantitative and verbal aptitude, and is a U.S. citizen/permanent resident. Regular admission and financial support applications must be received before February 1, 1982 to be considered. An extensive background in geological and cognate sciences is desirable. Unsuccessful applicants for the Exxon Fellowship are still eligible for our regular financial support. For further details contact: R. Van der Voo, Chairman, Department of Geological Sciences, University of Michigan, Ann Arbor 48109.

Graduate Study in Oceanography/Oceanographic Engineering. Research Assistantships and research fellowships are available for graduate study in Physical and Chemical Oceanography, Oceanographic Engineering, and Marine Geology and Geophysics leading to a Ph.D. or Sc.D. degree conferred jointly by the Woods Hole Oceanographic Institution and the Massachusetts Institute of Technology. The awards cover tuition and provide an average monthly taxfree stipend of $540 to $590. Research topics available to student reflect the interests of the more than 100 doctoral scientists and engineers at WHOI and the faculties of ten different departments at MIT.

The program encourages applications from students with an undergraduate degree in any of the natural sciences or engineering. For additional information please contact: The MIT/WHOI Joint Program in Oceanography/Oceanographic Engineering at either: The Education Office, The Woods Hole Oceanographic Institution, Woods Hole, MA 02543, or Room 54-911, The Massachusetts Institute of Technology, Cambridge, MA 02139.

Graduate Research Assistantships in Marine, Atmospheric, and Sedimentary Geochemistry. Available for studies leading to M.S. and Ph.D. degrees with specialization in the geochemistries of oceanic, estuarine, and sedimentary trace elements and nutrients, atmospheric particulates and gases, and sedimentary radiogeochemistry. Stipends for incoming M.S. candidates are $5700 for 9 mos., with additional summer awards up to $2800; and for advanced Ph.D. students are up to $10,000 for 12 mos. Persons with strong undergraduate majors in the basic sciences are encouraged to apply. Contact Prof. P. N. Froelich, Dept. of Oceanography, Florida State University, Tallahassee, FL 32306, 904/644-6700.

Meetings

Rock Mechanics Symposium

January 29 is the deadline for abstracts of papers for the 23rd U.S. Rock Mechanics Symposium, to be held August 25–27, 1982, at the University of California at Berkeley. Theme of the conference is 'Issues in Rock Mechanics.'

Extended abstracts of not more than three to four pages (double-spaced pages), including one or two figures, should be sent to the Organizing Committee, 23rd U.S. Rock Mechanics Symposium, c/o Richard E. Goodman, Department of Civil Engineering, University of California, Berkeley, CA 94720. Authors will be notified by March 1; completed papers, ready for publication, are due May 1.

The annual symposium is sponsored by the U.S. National Committee for Rock Mechanics. A final program will be available in May.

IAHS Scientific Assembly

The International Association of Hydrological Sciences (IAHS) will hold its Scientific General Assembly at the University of Exeter, England, from July 19 to 30, 1982. Previously, the general assemblies have been held within the general assemblies of the International Union of Geodesy and Geophysics; 1982 will be the first year since its foundation in 1922 that IAHS will hold its own general assembly.

Six symposia, each organized by one of the IAHS commissions, are planned: advances in hydrometry; optimal allocation of water resources; improvement of methods of long-term prediction of variations in groundwater resources and regimes caused by human activity; recent developments in the explanation and prediction of erosion and sediment yield; hydrological aspects of alpine and high mountain areas; and effects of waste disposal on groundwater and surface water. Poster sessions and workshops, including one on remote sensing and one on hydrology in developing countries, are planned.

Accommodations for meeting participants will be provided at the university. Those wishing to stay outside the university are urged to book hotel accommodations early. Contact the Tourist Information Centre, Civic Centre, Dix's Field, Exeter, Devon, UK.

For additional information on the assembly, contact D. E. Walling, Chairman, Local Organizing Committee, Department of Geography, University of Exeter, Amory Building, Exeter EX4 4RJ, UK.

The IAHS Assembly is being held at the invitation of the Royal Society, and the City and University of Exeter, with the support of UNESCO, WMO, and the UK Overseas Development Administration.

EGS and ESC Meeting

The European Geophysical Society (EGS) and the European Seismological Commission (ESC) will meet at the University of Leeds, England, on August 23–27, 1982. A call for papers has been issued. Travel awards are available for young scientists.

In addition to nearly 30 symposia, workshops, and open sessions, meetings will be held of all the ESC subcommissions: data acquisition, theory and interpretation, microseisms, deep seismic sounding, focal mechanisms, earthquake predictions, and seismicity. Sessions will be held on the IASPEI Commission on Practice and on the IASPEI Commission on Controlled Source Seismicity. Several working groups and coordinating committees of the Inter-Union Commission on the Lithosphere will also meet.

The symposia are divided into three sections: earth and planetary interiors and surfaces; hydrospheres and earth and planetary atmospheres; and interplanetary medium, magnetospheres, and upper atmospheres. Two society lectures entitled 'Rotating Fluids in Geophysics and Planetary Physics' and 'The Magnetospheres of Jupiter and Saturn' will be featured.

Travel awards are available for young scientists. Application forms are available from P. Steinhauser, Zentralanstalt fur Meteorologie und Geodynamik, A-1190 WIEN, Hohe Warte 38, Austria. March 31 is the closing date.

Potential contributors to the EGS symposia, workshops, or open sessions should send two copies of abstracts to J. Lemaire, Chairman, Program Committee, IAS, 3 Av. Circulaire, B 1180 Brussels, Belgium. For ESC symposia, workshops, or subcommissions, mail two copies of the abstract to J. M. Van Gils, Secretary of ESC, O. R. B., 3 Av. Circulaire, B 1180 Brussels, Belgium. One copy of the abstract also should be sent to the convenor of the sessions; the list of convenors, along with additional information and meeting circulars, can be obtained from J. T. Gleave, Special Courses Division, The University of Leeds, Leeds, LS2 9JT, U.K. (telephone: 0532 435036; Telex 557939 Expath G.).

International Mine Water Congress

The First International Mine Water Congress of the International Mine Water Association will be held April 19–24, 1982, in Budapest, Hungary. The meeting is organized by the Hungarian Mining and Metallurgical Society and the Central Institute for the Development of Mining; the sponsor is the Department of Geosciences of the Hungarian Academy of Sciences.

Topics to be covered include geoscience and engineering for the prediction and control of the hazards and damages caused by mine water; protection of mining and the miner against hazard; environmental protection and mine water control; and the relationship between the control and utilization of mine water.

For additional information, contact Zs. Kesseru, Hungarian Mining and Metallurgical Society, H-1061 Budapest, Anker köz 1-3, or Roy E. Williams, College of Mines, University of Idaho, Moscow, ID 83843.

GAP

Separates

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Aeronomy

0410 Absorption and scattering of radiation
IDENTIFICATION OF ACETYLENE (C_2H_2) IN INFRARED ATMOSPHERIC ABSORPTION SPECTRA
A. Goldman (Department of Physics, University of Denver, Denver, Colorado 80208), F.J. Murcray, R.D. Blatherwick, J.R. Gillis, F.S. Bonomo, F.H. Murcray, D.G. Murcray, and R.J. Cicerone.
Infrared atmospheric absorption spectra at ~0.02 cm^{-1} resolution obtained during a balloon flight made on 3/23/81 show absorption features attributable to C_2H_2. These features are used to derive a preliminary mixing ratio of ~25 pptv near 9 km. This mixing ratio falls into the range of values we calculate for upper tropospheric C_2H_2 in a photochemical/transport model but well below values measured previously in samples collected by other researchers.
J. Geophys. Res., Green, Paper 1C1573

0410 Absorption and scattering of radiation (particles or waves)
CONTRIBUTION OF SINGLY SCATTERED PHOTONS TO THE OPTICALLY THICK RESONANCE RADIATION FIELD OF THE HELIUM GEOCORONA
H.J. Fahr and T. Said (Institut für Astrophysik, Univ. Bonn, D-5300 Bonn, FRG)
Gas absorption cell photometry of the geocoronal helium resonance radiation field proves that singly scattered photons attain increasing importance if line center regions are suppressed. We attempt a quantitative confirmation of this observational finding and reinvestigate the radiation transport problem in terms of contributions of different scattering orders on the basis of angle-dependent partial frequency redistribution. The properties of the two lowermost scattering orders are studied in detail. The dominance of the first scattering order with increasing line center distance is explicitly shown. Beyond some critical line center distances the first order intensities are proven to be proportional to the helium column densities.
J. Geophys. Res., Blue, Paper 1A1450

Electromagnetics

0720 Electromagnetic theory
EFFECTS OF LATERAL IONOSPHERIC GRADIENTS ON ELF PROPAGATION
E. C. Field (Pacific-Sierra Research Corporation, 1456 Cloverfield Boulevard, Santa Monica, California 90404) and R. G. Joiner
This paper analyzes the propagation of the TEM ELF mode when the earth-ionosphere waveguide is not stratified. It treats a localized disturbance by recasting the wave equation as a two-dimensional integral equation. Numerical solutions show that such a disturbance behaves like a cylindrical lens filling a narrow aperture. Lateral diffraction, focusing, and reflection can cause the TEM mode to exhibit a standing wave pattern before the disturbance, and a transverse pattern of maxima and minima beyond it. Such phenomena can contribute to the spatial fluctuations occasionally observed in ELF transmissions. The focusing and diffraction diminish when the transverse dimension of the disturbance approaches the width of the first Fresnel zone—typically, several megameters. The analysis models exceedingly widespread inhomogeneities, such as a disturbed polar cap or the day/night hemispheres, as semi-infinite regions having diffuse boundaries. It then derives full-wave analytic expressions for the lateral reflection and transmission coefficients of the TEM mode. Reflection can be important in two situations: first, when a great-circle propagation path is nearly tangential to the boundary of the disturbed polar cap; second, when the TEM mode is obliquely incident on the day/night terminator—in which case a phenomenon analogous to internal reflection can occur.
Rad. Sci., Paper 1S1737

0770 Radio Oceanography
WAVEHEIGHT AND WIND SPEED MEASUREMENTS FROM THE SEASAT RADAR ALTIMETER
L.S. Fedor (NOAA/ERL/Wave Propagation Laboratory, Boulder, Colorado 80303) and G.S. Brown (Applied Science Associated, Inc. Apex, North Carolina 27502)
Comparisons between the SEASAT radar altimeter inferred estimates of significant waveheight (SWH) and wind speed with buoy measurements for near overflights are presented. Details of the "calibration" of SEASAT's measurement of $\sigma^0(0°)$ against the GEOS-3 radar altimeter are presented. The "on-board" estimate of SWH is shown to be biased high by 0.5 m for SWH > 2 m. Comparisons of buoy measurements of SWH with altimeter data processed using the Fedor algorithm for 31 cases show a mean difference of 0.07 m with a standard deviation of 0.29 m over the range of 0.5 to 5 m SWH. The SEASAT inferred estimates of $\sigma^0(0°)$ are biased high by 1.6 dB relative to GEOS-3 data. For 8? comparisons with buoy measurements of wind speed, the mean difference is -0.25 m/s and the standard deviation of the difference is 1.8 m/s over the range of 1 to 10 m/s wind speed. The numbers are very similar to GEOS-3 data comparisons and thus provide a second corroboration of the waveheight and wind speed measurement capability of a short pulse spaceborne radar altimeter.
J. Geophys. Res., Green, Paper 1C1663

0770 Radio oceanography
ATTENUATION WITH DISTANCE AND WIND SPEED OF HF SURFACE WAVES OVER THE OCEAN
F. Forget (Laboratoire de Sondages Electromagnétiques de l'Environnement Terrestre, 83100 Toulon, France), P. Broche and J.C. de Maistre
An HF monostatic experiment is performed for evaluating the relative attenuation with distance of radio waves propagating in the ground wave mode over the sea surface, at 7 and 14 MHz. A clear evidence of the wind speed (causing the sea roughness) influence rises from the data, particularly at 14 MHz. The results are checked to Barrick's theoretical calculations and a good agreement is found for the values of attenuation rates (in dB/Km) and their variation with the wind speed in the up/down wind case. Some discrepancies in the data are partially interpreted as due to a fetch influence upon the radar cross section.
Rad. Sci., Paper 1S1738

0773 Remote sensing
INTERCOMPARISON OF WIND SPEEDS INFERRED BY THE SASS, ALTIMETER, AND SMMR
F. J. Wentz (Remote Sensing Systems, Sausalito, California) V. J. Cardone (Oceanweather, Inc., White Plains, New York) and L. S. Fedor (Wave Propagation Laboratory, NOAA, Boulder, Colorado)
Seasat carried three wind speed microwave sensors: a scatterometer (SASS), an altimeter (ALT), and a five-frequency radiometer (SMMR). The winds inferred by these three sensors along with colocated in situ buoy anemometer measurements are intercompared. In general, the comparisons show an agreement of about 2 m/s with the three sensors tracking each other quite well. For nadir observations, all three instruments respond equally well to low winds, while there is a significant discrepancy at high wind speeds. The SASS overestimates the high nadir winds, whereas the ALT winds seem biased low. The SMMR high winds lie in between the SASS and ALT. The difference between the SASS and ALT winds is due to using a different model function in the geophysical processing and is not due to the sensor data. Off-nadir comparisons between the SASS and SMMR show a 1.5 m/s scatter on top of a bias that varies by about 1 m/s across the swath. In storms the agreement between SASS and SMMR degrades somewhat. However, both sensors respond to the high wind speeds (25 m/s), with neither instrument experiencing saturation.
J. Geophys. Res., Green, Paper 1C1684

0773 Remote sensing
A PARAMETERIZATION OF EFFECTIVE SOIL TEMPERATURE FOR MICROWAVE EMISSION
B. J. Choudhury (Hydrological Sciences Branch, NASA/Goddard Space Flight Center, Greenbelt, MD 20771) T. J. Schmugge and T. Mo
The observed microwave brightness temperature of soils depends upon the soil temperature profile, which in a remote sensing application will not be known in any detail. In this paper we discuss a parameterization of effective soil temperature, which when multiplied by the emissivity, gives the brightness temperature, in terms of surface (T_∞) and deep (T_0) soil temperatures as $T = T_\infty + C\,(T_0 - T_\infty)$. A coherent radiative transfer model and a large data base of observed soil moisture and temperature profiles are used to calculate the best-fit value of the parameter C. For 2.8, 6.0, 11.0, 21.0 and 49.0 cm wavelengths, the C values are respectively 0.802 ± 0.006, 0.667 ± 0.008, 0.480 ± 0.010, 0.246 ± 0.009, and 0.084 ± 0.005. The parameterized equation gives results which are generally within one or two percent of the exact values. (Radiative transfer, soil moisture, microwave, remote sensing)
J. Geophys. Res., Green, Paper 1C1646

Ocean Sciences: AGU/ASLO Joint Meeting

A joint meeting of the American Geophysical Union's Oceanography Section and the American Society of Limnology and Oceanography will be held February 16–19, 1982, in San Antonio, Texas

Registration. Everyone who attends the meeting must register. Preregistration (received by January 29) saves you time and money, and the fee will be refunded if AGU receives written notice of inability to attend by February 8.

Registration rates are as follows:

	Preregistration	At Meeting (after 1/29)
Member	$55	$70
Student Member	$25	$40
Nonmember	$75	$90
Student nonmember	$32	$47

Registration for 1 day only is available at half the above rates. Members of American Geophysical Union, American Society of Limnology and Oceanography, Marine Technology Society, and American Meteorological Society may register at the member rates.

The difference between member (or student member) registration and nonmember registration may be applied to AGU dues if a completed membership application is received at AGU by May 19, 1982. Current AGU annual membership rates are: $20 members; $7 student members.

To preregister, fill out the registration form, and return it with your payment to the AGU Office. Your receipt will be included with your preregistration material at the meeting. Preregistrants should pick up their registration material at the preregistration desk at the El Tropicano Hotel, headquarters for the meeting. Complimentary badges for guests not attending the scientific sessions will be available at the registration desk.

Hotel Accommodations. Blocks of rooms are being held at the El Tropicano, the St. Anthony, and the Gunter hotels. Read the housing application and MAIL THE COMPLETED APPLICATION FORM TO THE HOUSING DEPARTMENT, San Antonio Convention and Visitors Bureau, P.O. Box 2277, San Antonio, Texas, 78298. MAIL EARLY to insure confirmation at your preferred hotel. DEADLINE FOR RESERVATIONS IS JANUARY 15, 1982. Please do not write or call the AGU office for room reservations.

Social Events. Complimentary refreshments will be served daily from 9:30 to 10:30 A.M., from 2:30 to 3:30 P.M., and again at the Ice Breaker immediately following the session on Tuesday evening.

A luncheon is planned for Wednesday in the Southwest Craft Center, one of the Southwest's finest examples of French architecture of the late 1800's. Fred Spilhaus, Executive Director of AGU will speak on Society Collaboration—Strength for Ocean Sciences. Reserve early as space is limited. Cost-$8.75 per ticket.

Program Summary

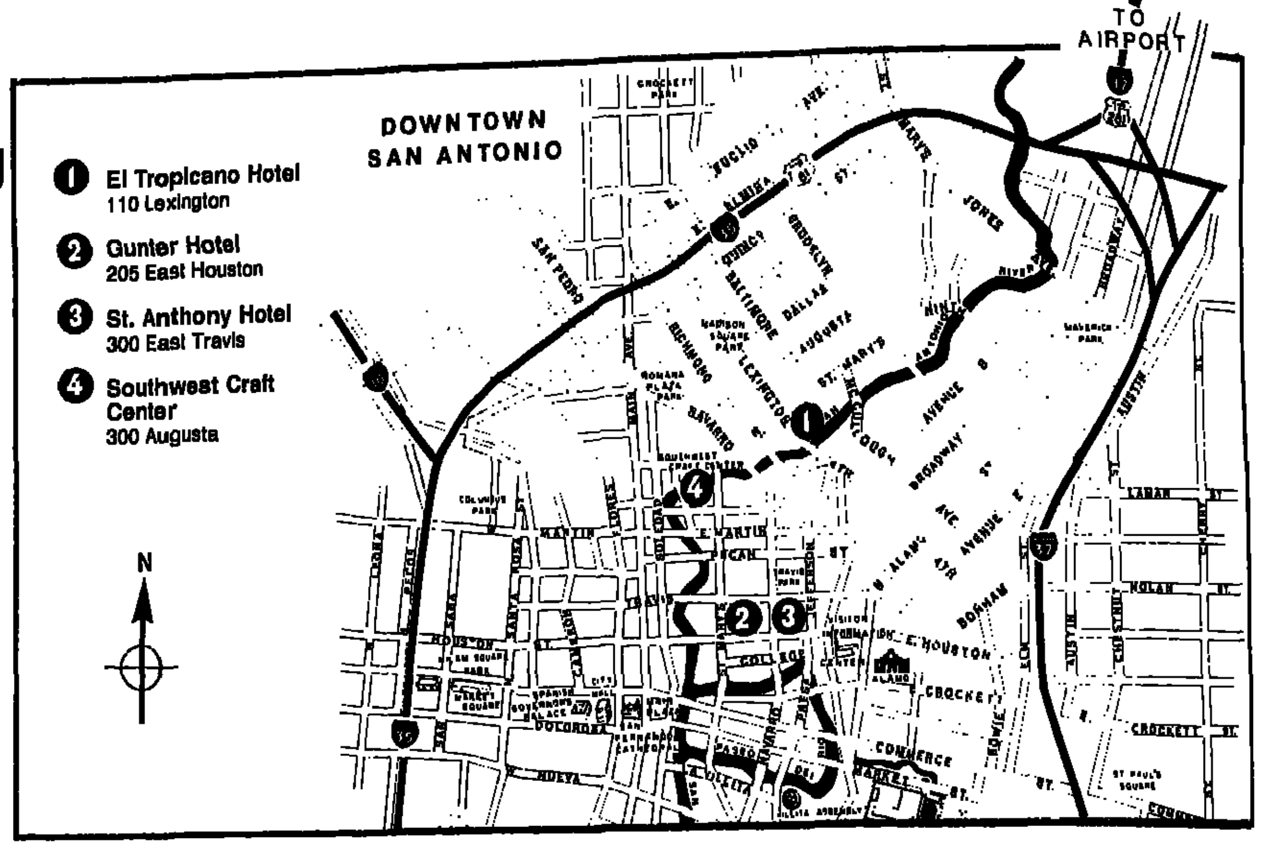
All of the sessions will be held in the El Tropicano Hotel.

Tuesday
- Particle Fluxes I (AM)
- Biology and Physics of Ice Edges (AM)
- Ocean-River Interaction (AM)
- Large-Lake Processes (AM)
- Rings (AM)
- Particle Fluxes II (PM)
- Biology and Physics of Ice Edges (PM)
- Ocean-River Interaction (PM)
- Large-Lake Processes (PM)
- Rings (PM)
- Marine Optics (PM)

Wednesday
- Large Oceanographic Program (AM)
- Biogeochemical Cycling (AM)
- SANOS (AM)
- Small-Lake Limnology (AM)
- Mesoscale Processes (AM)
- Large Oceanographic Programs (PM)
- Biogeochemical Cycling (PM)
- Geology and Circulation (PM)
- Small-Lake Limnology (PM)
- Mesoscale Processes (PM)

Thursday
- Antrhopogenic Inputs (AM)
- Feeding Dynamics (AM)
- Particle Fluxes III (AM)
- Coastal Processes I (AM)
- Climate and Productivity (AM)
- Anthropogenic Inputs (PM)
- Gulf of Mexico Biology and Circulation (PM)
- Particle Fluxes IV (PM)
- Coastal Processes II (PM)
- Microscale Processes (PM)

Friday
- Microbial Dynamics (AM)
- PROBES (AM)
- Measurement Techniques (AM)
- Coastal Processes III (AM)
- Bioturbation (AM)
- Microbial Dynamics (PM)
- General Oceanography (PM)
- Measurement Techniques (PM)
- Trace Metals (PM)
- Bioturbation (PM)



Ocean Sciences: AGU/ASLO Joint Meeting

February 16–19, 1982
San Antonio, Texas

IMPORTANT INSTRUCTIONS

The San Antonio Convention and Visitors Bureau will make hotel assignments upon receipt of the official housing application, provided that it is properly filled out and all necessary information is given. All rooms will be assigned on a first come, first serve basis. All requests must be on this form. Telephone requests *are not* accepted. OFFICIAL HOTEL CONFIRMATION WILL ADVISE DEPOSIT POLICY. DO *NOT* SEND MONEY WITH THIS FORM.

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The program and meeting abstracts will appear in the January 19 issue of Eos, which is mailed to all members of AGU/ASLO in advance of the meeting.

Ocean Sciences: AGU/ASLO Joint Meeting
February 16–19, 1982
San Antonio, Texas

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0773 Remote sensing
INFERENCE OF REFRACTIVITY PROFILES BY SATELLITE-TO-GROUND RF MEASUREMENTS
K. D. Anderson (Electromagnetic Propagation Division, Naval Ocean Systems Center, San Diego, CA 92152

A technique is described to infer an estimate of the tropospheric radio refractive index distribution from earth-based observations of a satellite borne beacon. The inference is accomplished by a statistical comparison between the observed interference pattern and a library of patterns generated from a family of assumed profiles. Experimental results show that the technique correctly predicts the ducting environment in twelve of twenty-two observations. However, the overall reliability of inferring the dominant features of the duct is not adequate for operational usage (Tropospheric, Inference, Refractivity, Propagation).
Rad. Sci., Paper 1S1652

Exploration Geophysics

0920 Magnetic and electrical methods
RESPONSE OF A LAYERED EARTH TO THE CRONE PULSE ELECTROMAGNETIC SYSTEM
S. K. Verma (National Geophysical Research Institute, Hyderabad 500 007, India) S. S. Rai

The response of a layered earth to the Crone pulse electromagnetic (PEM) systems, which measures the decay of the time derivative $\dot{H}_z(t)$ has been computed. The transient vertical magnetic field component $H_z(t)$ due to a vertical magnetic dipole is obtained by applying a Fourier series summation approach and using digital linear filters to compute the response at individual frequencies. Oscillations in $H_z(t)$ due to Gibb's phenomena are suppressed with Lanczos weights, and the derivative $\dot{H}_z(t)$ is computed numerically by using a linear difference approximation over five points.

Decay curves for various half-spaces are found to cross each other at different values of time. Thus, a single channel response cannot be used to estimate the half-space resistivity uniquely. This can be achieved, however, by making use of responses at two different channels. Conductivity-aperture diagrams for half-space models are plotted for both $H_z(t)$ and $\dot{H}_z(t)$, all the channel amplitudes show well-defined peaks in the range of 0.3 to 5 Ω-m, whereas for $\dot{H}_z(t)$ these peaks lie in the range of 0.7 to 20 Ω-m. This supports the finding by earlier workers that for higher conductivities a total field measuring system responds better than a derivative measuring system.

A theoretical formulation is presented to compute the Crone PEM response of an n-layered earth model. After checking the accuracy of the program, some results are presented for models with different numbers of layers. However, detailed investigation is reported for two-layered earth only. It is found that overburden parameters can be determined by utilizing responses at two different channels. Nomograms to determine these parameters are presented. There nomograms reveal that for the resistive basement case the best discrimination can be done for the overburden resistivities in the range of 3 to 10 Ω-m and for thicknesses in the range of 0.5 ℓ to 1.5 ℓ (ℓ being the coil separation). For the conductive basement situation the corresponding values are 3 to 15 Ω-m and 0.25ℓ to 1ℓ.
GEOPHYSICS, VOL. 47, NO. 1

0920 Magnetic and electrical methods
MAGNETOTELLURIC RESPONSE ON VERTICALLY INHOMOGENEOUS EARTH HAVING CONDUCTIVITY VARYING EXPONENTIALLY WITH DEPTH
D. Rao (Department of Physics, University of York, Heslington, York YO1 5DD, England)

Magnetotelluric (MT) response is studied for a vertically inhomogeneous earth, where conductivity (or resistivity) varies exponentially with depth as $\sigma(z)=\sigma_0\exp(pz)$. Horizontal electric and magnetic fields in such an inhomogeneous medium are given in terms of modified Bessel function. Impedance and apparent resistivity are calculated for (1) an inhomogeneous half-space having conductivity varying exponentially with depth, (2) an inhomogeneous half-space overlain by a homogeneous layer, and (3) a three-layer model with the second layer as an inhomogeneous of transitional layer. Results are presented graphically and are compared with those of homogeneous multilayer models. In the case of resistivity increasing exponentially with depth, the results of the above inhomogeneous models are equivalent to those of Cagniard two-layer models, with $h_{1e}=h_1+|1/p|$. In the case of resistivity decreasing exponentially with depth, the homogeneous multilayer approximation depends upon the number of layers and the layer parameters chosen; $|Z/\omega\mu|$ as a function of frequency is more useful than the apparent resistivity in determining the values of p and h_1.
GEOPHYSICS, VOL. 47, NO. 1

0920 Magnetic and electrical methods
EULDPH: A NEW TECHNIQUE FOR MAKING COMPUTER-ASSISTED DEPTH ESTIMATES FROM MAGNETIC DATA
D. T. Thompson (Gulf Research and Development Company, P. O. Drawer 2038, Pittsburgh, PA 15230)

A method for rapidly making depth estimates from large amounts of magnetic data is described. The technique is based upon Euler's homogeneity relationship (hence, the acronym EULDPH) and differs from similar techniques which are currently available in that no basic geologic model is assumed. Therefore, EULDPH can be applied in a wider variety of geologic situations than can model-dependent techniques. The price paid for this increased flexibility is a heavier burden on the interpreter. Successful interpretation of EULDPH results is partially dependent upon the interpreter's intuitive understanding of the concept of the equivalent stratum and also partially dependent upon experience with model studies. The theoretical basis, the computational algorithm, and applications of EULDPH to model and real data are illustrated.
GEOPHYSICS, VOL. 47, NO. 1

0920 Magnetic and electrical methods
ASYMPTOTIC EXPANSIONS FOR TRANSIENT ELECTROMAGNETIC FIELDS
T. Lee (Formerly Cooperative Institute for Research in Environmental Sciences/NOAA, University of Colorado; presently, P. O. Box 386, Epping, N.S.W. 2121, Australia)

Asymptotic expansions may be derived for transient electromagnetic (EM) fields. The expansions are valid when $\sigma\mu_0 l^2/t$ is less than about 0.1. Here l, σ, μ_0, and t are the respective lengths, conductivities, permeabilities of free space and time.

Cases for which asymptotic expansions are presented include (1) layered grounds, (2) axisymmetric structure, and (3) two-dimensional (2-D) structures.

In all cases the transient voltage eventually approaches that of the host medium alone, the ratio of anomalous response to the half-space response being proportional to $1/t^{\nu}$. Here ν is equal to 0.5 for layered structures and 1.0 for 2-D or 3-D structures.
GEOPHYSICS, VOL. 47, NO. 1

0920 Magnetic and electrical methods
THE RESPONSE OF PERTURBATION AND INDUCTION ARROWS TO A THREE-DIMENSIONAL BURIED ANOMALY
K-L. Lam (Department of Physics and the Institute of Earth and Planetary Physics, University of Alberta, Edmonton, Alta., Canada T6G 2J1) F. W. Jones, and R. D. Hibbs

A numerical model is employed to calculate theoretical perturbation and induction arrows for a spatially confined three-dimensional (3-D) conductivity anomaly located at various depths below the surface of the earth for two source periods. The results indicate that the magnitudes of the induction arrow decrease as the anomaly depth increases and the arrows point toward the conductive anomaly even at great depth below the surface. It is found that the extent of the anomalous induced currents depends upon the depth of the inhomogenuity and on the source field period. The (p + q) perturbation arrow can be used to outline the spatial extent of the anomaly, and the (p + q) quadrature-phase arrows better indicate the spatial extent than the in-phase arrows if the source period is not an optimum one.
GEOPHYSICS, VOL. 47, NO. 1

0920 Magnetic and electrical methods
TRANSIENT ELECTROMAGNETIC CALCULATIONS USING THE GAVER-STEHFEST INVERSE LAPLACE TRANSFORM METHOD
J. H. Knight (CSIRO Division of Mathematics and Statistics, P.O. Box 1965, Canberra City, A.C.T. 2601, Australia) A. P. Raiche

Calculations for the transient electromagnetic (TEM) method are commonly performed by using a discrete Fourier transform method to invert the appropriate transform of the solution for TEM soundings over an N-layer earth and show how to use the Gaver-Stehfest algorithm to invert it numerically. This is considerably more stable and computationally efficient than inversion using the discrete Fourier transform.
GEOPHYSICS, VOL. 47, NO. 1

0920 Magnetic and electrical methods
CONTROLLED-SOURCE AUDIOMAGNETOTELLURICS IN GEOTHERMAL EXPLORATION
Stewart K. Sandberg (Amoco Minerals Co., 333 West Hampden, Englewood, CO 80110) Gerald W. Hohmann

Theoretical and field tests indicate that the controlled-source audiomagnetotelluric (CSAMT) method produces an efficient means of delineating the shallow resistivity pattern above a hydrothermal system. Utilizing a transmitter overcomes the main limitation of conventional audiomagnetotellurics—variable and unreliable natural source fields. Reliable CSAMT measurements can be made with a simple scalar receiver. Our calculations for a half-space show that the plane-wave assumption is valid when the transmitter is more than 3 skin depths away in the broadside configuration and more than 5 skin depths away in the collinear configuration. Three-dimensional (3-D) numerical modeling results for a dipole source 5 skin depths away compare well with those for a plane-wave source, showing that the method is valid.

A CSAMT survey at the Roosevelt Hot Springs geothermal area in Utah produced apparent resistivity contour maps at four frequencies: 32, 98, 977, and 5208 Hz. These maps show the same features as those of a dipole-dipole resistivity map. We also collected detailed CSAMT data at 10 frequencies on two profiles. Two-dimensional (2-D) plane-wave modeling (transverse magnetic mode) of the resulting pseudo-sections yields models similar to those derived by modeling the dipole-dipole resistivity data. However, CSAMT resolved details not shown by the resistivity modeling. Thus, high resolution along with an efficient field procedure make CSAMT an attractive tool for geothermal exploration.
GEOPHYSICS, VOL. 47, NO. 1

0920 Magnetic and electrical methods
IONOSPHERIC INDUCED VERY LOW-FREQUENCY ELECTRIC FIELD WAVETILT CHANGES
See 5545 Ionospheric disturbances
D. V. Thiel (School of Science, Griffith University, Nathan, Q. 4111, Australia) I. J. Chant

Very low-frequency (VLF) electric field wavetilt measurements were made continuously over a period of four months at a fixed location. Daytime and nighttime values of the wavetilt were found to be relatively constant. During sunrise and sunset the wavetilt measurements were meaningless for two three-hour intervals during a 24 hour period. A mechanism involving modal interference is postulated. This phenomenon may be a problem in other passive electromagnetic (EM) prospecting systems including audiofrequency magnetic and audiomagnetotellurics.
GEOPHYSICS, VOL. 47, NO. 1

0930 Seismic methods
SEISMIC ATTENUATION: EFFECTS OF PORE FLUIDS AND FRICTIONAL SLIDING
See 6940 Phenomena related to earthquake prediction
Kenneth W. Winkler (Schlumberger-Doll Research, P.O. Box 307, Ridgefield, CT 06877) Amos Nur

Seismic wave attenuation in rocks was studied experimentally, with particular attention focused on frictional sliding and fluid flow mechanisms. Sandstone bars were resonated at frequencies from 500 to 9000 Hz, and the effects of confining pressure, pore pressure, degree of saturation, strain amplitude, and frequency were studied. Observed changes in attenuation and velocity with strain amplitude are interpreted as evidence for frictional sliding at grain contacts. Since this amplitude dependence disappears at strains and confining pressures typical of seismic wave propagation in the earth, we infer that frictional sliding is not a significant source of seismic attenuation in situ. Partial water saturation significantly increases the attenuation of both compressional (P) and shear (S) waves relative to that in dry rock, resulting in greater P-wave than S-wave attenuation but causes a reduction in P-wave attenuation. These effects can be interpreted in terms of wave induced pore fluid flow. The ratio of compressional to shear attenuation is found to be a more sensitive and reliable indicator of partial gas saturation than is the corresponding velocity ratio. Potential applications may exist in exploration for natural gas and geothermal steam reservoirs.
GEOPHYSICS, VOL. 47, NO. 1

0930 Seismic methods
INFORMATION THEORETIC PROCESSING OF SEISMIC DATA
R. Inguva and L. H. Schick (Physics Department, University of Wyoming, Laramie, Wyoming 82071)

The principle of maximum entropy with a χ^2 constraint is developed as a stacking technique for seismic data. The formalism is applied to the stacking of single correlated Vibroseis traces. The computational results can differ significantly from those of a mean stack. They also illustrate the effectiveness of the method in the relative reduction of noisy amplitudes compared to those that are less noisy. (Information theory, seismic data).
Geophys. Res. Lett., Paper 1L1687

0930 Seismic methods
SEISMIC Q—STRATIGRAPHY OR DISSIPATION
T. W. Spencer (Department of Geophysics, Texas A & M University, College Station, TX 77843) J. R. Sonnad, and T. M. Butler

The basic problems encountered in extracting estimates of seismic dissipation from data recorded on vertical seismic profiles are analysed. Because anomalous dissipation in the subsurface is likely to be associated with conditions or lithologies of limited vertical extent, a knowledge of the factors which influence the spatial resolution of an attenuation measurement is of considerable importance.

By introducing a statistical perspective, it is possible to simulate multiple measurements in an inhomogeneous interval and to draw conclusions which apply to an entire class of impedance structures. Theoretical seismograms are analysed to demonstrate that for small receiver separations neither a single measurement nor the mean value determined from multiple measurements is likely to give a good estimate of the attenuation for an inhomogeneous depth interval. For small receiver separations, the attenuation computed from the amplitude ration method is much more strongly influenced by the local stratigraphy in the immediate vicinity of the seismometer than by the attenuation in the depth interval between seismometers. As the seismometer separation increases, there is a dramatic decrease in the variability in the attenuation values determined from multiple measurements. A critical distance can be defined which is a measure of the spatial resolution. Beyond the critical distance the mean value approaches a quantity which is the sum of two components: the effective dissipation for an inhomogeneous interval and a stratigraphic term which describes the attenuation in a nondissipative system.
GEOPHYSICS, VOL. 47, NO. 1

Geodesy and Gravity

1910 High-order harmonics
THE INVERSE PROBLEM OF CONSTRUCTING A GRAVIMETRIC GEOID
V. Zlotnicki (Joint Program in Oceanography, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139 and Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543), B. Parsons and C. Wunsch

Computation of a single geoidal height from gravity acceleration data formally requires that the latter be known everywhere on the earth. We present a computational procedure based on linear inverse theory for estimating geoidal heights from incomplete sets of data. The same scheme can be used to estimate gravity accelerations from altimetry-derived geoids. The systematic error due to lack of data and the choice of a particular inverse operator is described using resolution functions and their spherical harmonic expansions. An rms value of this error is also estimated, by assuming a spectrum for the unknown geoid. The influence of the size of the data region, the spacing between data, the filtering applied to the data, and the model weighting function chosen, are all quantified in a spherical geometry. The examples presented show that when low degree spherical harmonic coefficients are available – from satellite orbit analysis – a bandpassed version of the geoid can be constructed from local gravity data, even with a relatively restricted data set. (Geoid, linear inversion).
J. Geophys. Res., Red, Paper 1B1733

1990 Instruments and techniques
THE EFFECT OF DIPPING BEDS ON A BOREHOLE GRAVIMETER SURVEY
A. R. Brown (Formerly Amoco Production Co.; presently Cities Service Company, P. O. Box 300, Tulsa, OK 74102) T. V. Lautzenhiser

We study the effects of dipping beds on a borehole gravimeter (BHGM) survey. A dipping bed solution is presented which uses an anomalous bed density in a regional framework. A method of application is shown which provides an estimate of the regional framework density and dip angle of the beds. The method of application requires measuring local formation density independently.
GEOPHYSICS, VOL. 47, NO. 1

Geomagnetism and Paleomagnetism

2560 Time variations, paleomagnetism
LATE CRETACEOUS-EARLY TERTIARY PALEOMAGNETISM OF ARUBA AND BONAIRE (NETHERLANDS LEEWARD ANTILLES)
Carola Stearns (Department of Geological Sciences, University of Michigan, Ann Arbor, Michigan 48109) Frederick J. Mauk and Rob Van der Voo

For a paleomagnetic study of the Upper Cretaceous of the Netherlands Leeward Antilles, we have analyzed 187 oriented samples from the complex norite-tonalite batholith and the diabase-schist-tuff formation on Aruba and 44 oriented samples from various igneous units of the Washikemba formation on Bonaire. Both alternating field (AF) and thermal demagnetization procedures were used to demagnetize the samples. Most of the cores yielded univectorial Zijderveld diagrams above 10-20 milliTeslas or 400°C. Virtual geomagnetic poles (VGP's) calculated from site means were then compared with equivalently aged poles from cratonic South America and other Caribbean sites. The Washikemba Formation of Bonaire and the diabase-schist-tuff formation of Aruba yield poles that are similar to those of Guajira (Colombia) and the Caribbean Mountains of northern Venezuela, whereas they are rotated approximately 90° with respect to the pole for stable South America. The batholith on Aruba yields a pole which is rotated clockwise over approximately 20° with respect to the South American pole. Thus, our data strongly support the hypothesis that Aruba and Bonaire have been rotated clockwise by as much as 90° since the Late Cretaceous. In addition, paleolatitudes calculated from the inclinations of the paleomagnetic vectors suggest that there was a northward drift with respect to South America of perhaps as much as 10° of the islands during the rotation, although this can hardly be called a statistically significant amount. (Paleomagnetism, Caribbean, microplate rotation).
J. Geophys. Res., Red, Paper 1B1301

Geomagnetism and Aeronomy
Volume 21, Number 3

Bakharova M. F., Tverskoi B. A. Variations of particle energy in an alternative interplanetary electromagnetic field . . . 401
Kichatinov L. L., Matyukhin Yu. G. Transport of cosmic rays during the non-isotropic turbulence of IMF . . . 412
Nosov S. F. Distribution of cosmic rays in solar wind with an ellipsoidal boundary 420
Kaminer N. S., Kuzmicheva A. E., Mimrina N. V. Anizotropy near the boundary of cosmic rays of high-speed stream of solar wind . . . 425
Mineev Yu. V., Spirkova E. S. Streams and spectra of electrons with E=0,3–+3 MeV in the transition region by the data of the ASE «Prognoz-4» . . . 248
Lotova N. A., Chashei I. V. Distribution of velocities in a picture of scintillations and jet structure of solar wind . . . 435
Vlasov V. I. About a possibility of forecasting of geophysical activity by interplanetary scintillations of radiosources . . . 441
Vaskov V. V., Vyaznikov V. V., Golyan S. F., Gruzdev Yu. V., Gurevich A. V., Kim V. Yu., Lobachevsky L. A., Migulin V. V., Panchenko V. A., Petrov M. S., Polimatidi V. P., Sergeenko O. S., Sitnikov V. L., Kharkov I. P., Shluger I. S., Yurin K. I. Experimental investigation of effects of selfinfluence of powerful radiowaves at the gyrofrequency of electrons in F-region of the ionosphere by a Doppler method . . . 445
Vasiliev G. V., Goncharov L. P., Kushnerevsky Yu. V., Migulin V. V., Filgel M. D., Shaulin Yu. N. Preliminary results of the outer ionosphere sounding from aboard ASE «Intercosmos-19» . . . 451
Kapustina O. V., Mikhailova G. A., Mikhailov Yu. M. Peculiarities of amplitude spectra of whistlers at the frequencies lower than 1 kHz (ASE «Intercosmos-5 and -14») . . . 457
Lois L. To the estimation of ionospheric parameters by Doppler method . . . 463
Alimov V. A., Rakhlin A. V. Perspectives of modelling of unhomogeneous structure of ionosphere and forecasting of ionospheric scintillations of radiosignals 466
Agarishev A. I. Peculiarities of super-far propagation of decameter radiowaves in the period of high solar activity . . . 472
Kochnev V. A., Shutte N. M. Results of complex measurements of neutral composition of the upper atmosphere at the rocket «Vertical-4» . . . 476
Skubenitch V. V., Sapesochny I. P. Excitation of molecular ion states when monoenergetic electrons collide with molecules of atmospheric gases. I. Ion N_2^+ (spectral bands) . . . 481
Ginzburg E. I., Kuzin G. I. The effect of field swelling of short inner gravitational waves as possible cause of turbulazation of the mezosphere and lower thermosphere . . . 489
Dvinskykh N. I., Dolgoarchinnych B. G., Pisanko Yu. V., Rudneva N. M. About geomagnetic effects of high-speed streams in solar wind . . . 497
Kropotkin A. P. On the origin of anomalous resistivity and longitudinal electric fields on auroral field lines . . . 501
Iljin V. G., Miklukhina L. D., Osipov N. K. Electrons of the plasma sheet on geostationary orbits . . . 506
Antonova A. E., Filgel D. S. Influence of geomagnetic field structure and plasma density distribution on Pc1 pulsation propagation in the Earth's magnetosphere . . . 511
Kopilkov V. R. A new method of calculation of magnetotelluric impedance . . . 517
Rolanova N. M. About a spectrum-time analysis of mean annual values of elements of geomagnetic field . . . 524
Brodsky Yu. A. About a possibility of generation of magnetic field with unhomogeneous distribution of conductivity. III . . . 531

Brief Information

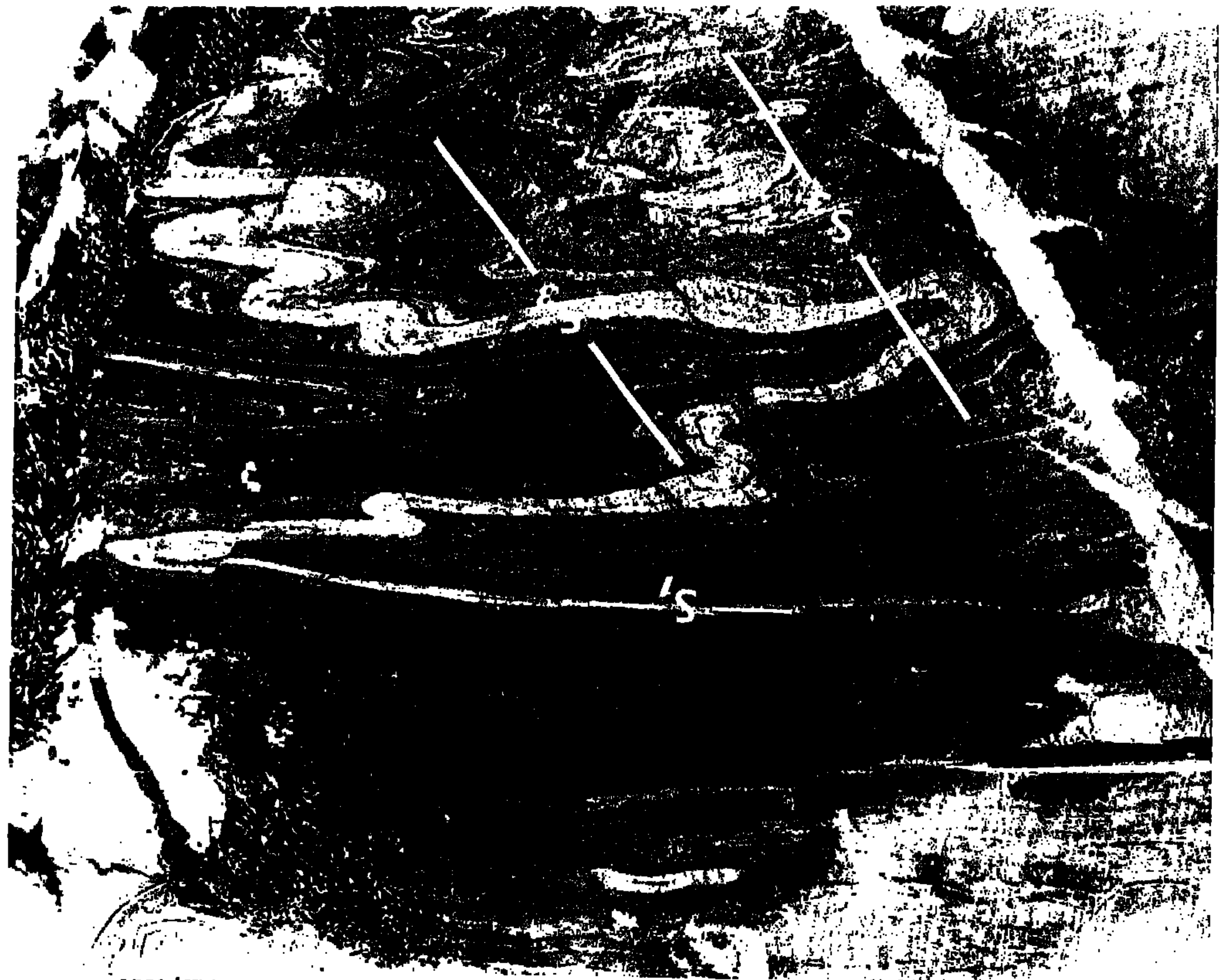
Samsonov I. S., Grigoriev V. G., Samsonova Z. N., Chirkov N. P. About the nature of variation of cosmic ray anizotropy with the cycles of solar activity . . . 536
Vernova E. S., Dorman L. I., Pilizina N. G., Tyasto M. I. The character of influences of coronal holes on cosmic ray intensity depending on particle energy . . . 538
Plotnikov I. Ya., Shadrina L. P. Comparison of geoeffectivity of disturbances of solar wind velocity and IMF in the period of solar activity increase . . . 541
Ivanov V. B., Pavlov N. N. About effects of ohmical heating by powerful radiowaves . . . 543
Bakal A. S., Russkin V. M., Solodovnikov G. K., Fatkullin M. N. Energy spectra of fluctuations of electron concentration in the outer ionosphere . . . 545
Sukhodoev V. A. Sources and duration of inner gravitational waves . . . 548
Kukushkina R. S., Lyatzkaya A. M. Influence of longitudinal currents on ionosphere of aurorae zone . . . 549
Kalinin Yu. K., Romanchuck A. A. About estimation of variation of frequency of transionospheric VHF-signals on account of large-scale irregularities of the outer ionosphere . . . 552
Bukin G. V. About division of magnetospheric SW-signal . . . 554
Kochenova N. A., Filgel M. D. About a possible cause of a week cyclic variation of radiowave absorption in high latitudes . . . 556
Zibulsky V. P., Kitaev V. V. Characteristics of the envelope of back-scatter sounding signals . . . 558
Bukin G. V. A magnetospheric signal in the presence of the ionosphere heating 561
Tshepkin L. A., Vinitsky A. V., Sukhodol'skaya A. N. Longitudinal anizotropy in daily variations of gas composition of the thermosphere above Antarctic . . . 563
Antonova L. A., Katyushina V. V. Estimation of latitudinal variations of a relative amplitude of semi-annual variations of atomic oxygen in the upper atmosphere of the Earth . . . 565
Mansurov S. M., Troshichev O. A., Zaitzev A. N., Papitashvili V. O., Timofeev G. A., Kandiboiotskaya M. A. Peculiarities of magnetic disturbances caused by IMF in the Southern polar cap . . . 567
Larkina V. I., Sizova L. Z. Dynamics of magnetospheric ring current by observations of VLF-radiation . . . 570
Potapov A. S., Polyakov A. R. About dependence of location of highlatitudinal maximum of Pc3 on pulsation period . . . 572
Onufrienock V. V., Zvegintzev A. G. Temperature magnetic hysteresis of pirrotines . . . 575

Chronicle

Fifth All-Union seminar on the VLF-emissions . . . 578
Nikolai Vasilievich Pushkov . . . 580

Bibliography

The middle atmosphere . . . 583
Annotations of the paper on geomagnetism and aeronomy in «New of the higher educational institutions. Radiophysics» . . . 584



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Hydrology

3175 Soil moisture
MOISTURE AND HEAT TRANSPORT IN HYSTERETIC, INHOMOGENEOUS POROUS MEDIA: A MATRIC HEAD-BASED FORMULATION AND A NUMERICAL MODEL.
P. Christopher D. Milly, Ralph M. Parsons Laboratory, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139

A general, physically-based formulation of water and energy transport in partially saturated soil must account for the coupling between the fields of matric potential (ψ) and temperature (T). The formulation by de Vries (1958) is converted to one that employs ψ and T as the dependent variables. This conversion facilitates a significant generalization of the theory to accommodate the omnipresent complications of hysteresis and inhomogeneity. The limitations of the assumptions of local thermodynamic equilibrium are discussed. A finite element solution algorithm for the one-dimensional equations is outlined and tested on a variety of problems. The computational results demonstrate the reliability of the numerical model. (Unsaturated zone, numerical analysis, porous media, heat flow).
Water Resour. Res., Paper 1W1684

3190 Instruments and techniques
A LOW-COST MULTICHANNEL RECORDING PIEZOMETER SYSTEM FOR WETLAND RESEARCH
H. Hemond (Massachusetts Institute of Technology, 48-419, Cambridge, Mass. 02139)

A low-cost system for the continuous recording of piezometric head is described. The system uses inexpensive earphones as sonar transducers, while using the narrow stem of the piezometers as an acoustic waveguide. The system overcomes several of the problems commonly encountered in tidal wetland investigations by providing rapid response, freedom from operator disturbance through peat compression, and essentially continuous automatic data recording in a directly machine-readable medium.
Water Resour. Res., Paper 1W1593

Meteorology

3770 Particles and Aerosols
STRATOSPHERIC AEROSOL AND CONDENSATION NUCLEI ENHANCEMENTS FOLLOWING THE ERUPTION OF ALAID IN APRIL 1981.
D. J. Hofmann (Department of Physics and Astronomy, University of Wyoming, Laramie, Wyoming, 82071), and J. M. Rosen.

A significant enhancement of the stratospheric aerosol and condensation nuclei levels was observed at Laramie, Wyoming beginning in May 1981, following the eruption of the volcano Alaid (50.8°N, 155.5°E) on April 28. Observations to mid-July suggest that in terms of effects on the stratosphere, the eruption was similar to that of Mt. St. Helens in May 1980. (Stratospheric aerosols, volcanic particles).
Geophys. Res. Lett., Paper 1L1635

3770 Particles and aerosols
THE TEMPERATURE DEPENDENCE OF THE FORMATION OF SULFATE AEROSOLS IN THE STRATOSPHERE
Glenn K. Yue and Adarsh Deepak (Institute for Atmospheric Optics and Remote Sensing (IFAORS), P. O. Box P, Hampton, Virginia [illegible])

Recent research has shown that [illegible] particles in the stratosphere cannot be formed through homogeneous [illegible] nucleation process. However this conclusion is obtained by assuming the ambient temperature to be -50°C or -55°C, but in reality it is not unusual that in certain regions of the stratosphere temperature can be as low as -75°C or even lower. In order to assess the influence of temperature on the formation of sulfate aerosols in the stratosphere, and to explore the possibility of forming new particles through homogeneous nucleation processes at certain regions where the temperature is extremely low, the classical nucleation theory is applied to calculate the temperature dependence of the characteristics and nucleation rates of sulfate aerosols in the binary H_2SO_4 - H_2O vapor mixture. Our calculated results indicate that the number of new particles formed at a lower temperature is orders-of-magnitude larger than that at a higher temperature when the concentration of water and sulfuric acid vapors are kept constant. At stratospheric regions with low temperature there may exist large amounts of ultrafine particles which can hardly be detected by conventional methods.
J. Geophys. Res., Green, Paper 1C1649

3799 General Meteorology (Atmospheric Ozone)
ANALYSIS OF TOTAL OZONE DATA FOR THE DETECTION OF RECENT TRENDS AND THE EFFECTS OF NUCLEAR TESTING DURING THE 1960's
G. C. Reinsel (Department of Statistics, University of Wisconsin, Madison, Wisconsin, 53706)

Time series modeling of monthly total ozone data is considered for the detection of changes in ozone due to the possible effects of nuclear weapons testing in the early 1960's and more recent effects of the release of chlorofluromethanes (CFMs). Based on ozone data from a network of ground-based Dobson recording stations over the period 1958-1979, the results of this analysis are consistent with a maximum decrease in total ozone in the northern hemisphere of approximately 2 to 4.5% due to nuclear testing effects in the early 1960's. More importantly, our findings show little evidence of any significant trend in global total ozone occurring in the 1970's, with the global change during 1970-1979 estimated as (.49 ± 1.35)%. (Total ozone, time series models, nuclear weapons testing effects, trends).
Geophys. Res. Lett., Paper 1L1627

Mineralogy, Petrology, and Crystal Chemistry

3640 Paragenesis, petrography and petrogenesis.
ALTERATION IN THE IRDP DRILLHOLE COMPARED WITH OTHER DRILLHOLES IN ICELAND.
H. Kristmannsdóttir (National Energy Authority, Grensásvegur 9, Reykjavík, Iceland).

In general the rock alteration in the IRDP drillhole at Reyðarfjörður is very similar to alteration patterns observed in Icelandic geothermal areas and in low grade metamorphosed basalts in deep crustal sections elsewhere in Iceland. The drillhole starts in the laumontite zeolite zone extending deeper into the chlorite - epidote alteration zone. However more detail is obtained by the study of the IRDP drillcore than by study of drill cuttings sampled in previous drillholes in Iceland. [illegible]

Tectonophysics

8150 Plate tectonics
KINEMATIC EVOLUTION OF THE NORTHERN COCOS PLATE
F. S. Schilt and D. E. Karig (Department of Geological Sciences, Cornell University, Ithaca, New York 14853)
M. Truchan (Lamont-Doherty Geological Observatory, Columbia University, Palisades, New York 10964)

As the East Pacific Rise approached and impinged upon the western margin of North America, the Farallon Plate began to break into multiple smaller plates, whose relative movements changed strongly from those before breakup. Movements of the northern Cocos plate, inferred from magnetic lineations, show rapidly changing rates and pole positions which may be characteristic of other small remnants of the Farallon plate. Finite difference poles and rates for Cocos-Pacific relative motion during the time intervals 2-5, 5-7, 7-10, and 10-14 my have been determined from the geometry of magnetic isochrons. Prior to about 2 my, the Cocos-Pacific pole was 10-20 degrees south of its present location, and angular rates were 2-4 times the present rate. From 10-7 my, we deduce a large degree of oblique convergence between the Cocos and North American plates, which may be an important constraint on the evolution of the structure of the continental margin of southwestern Mexico. The Tehuantepec Ridge originated as the ridge-ridge transform which generated the Clipperton fracture zone. Spreading rate estimates for the southern part of the Cocos plate suggest the possibility that the Tehuantepec Ridge was reactivated as a ridge-trench transform between the two Cocos plate fragments prior to about 7 my.
J. Geophys. Res., Red, Paper 1B1698

8150 Plate tectonics
THE CENOZOIC DENALI FAULT SYSTEM AND THE CRETACEOUS ACCRETIONARY DEVELOPMENT OF SOUTHERN ALASKA
Béla Csejtey, Jr. (U.S. Geological Survey, Menlo Park, California, 94025), D. P. Cox, R. C. Everts, G. D. Stricker, and H. L. Foster

The juxtaposition of disparate geologic terranes in southern Alaska has been previously interpreted to be mainly the result of several hundred kilometers of right-lateral offset along the Denali fault system in Cenozoic time. Recent geologic investigations in the Healy quadrangle strongly suggest that Cenozoic horizontal displacements of such magnitude along the Denali fault system do not exist. In the Healy quadrangle, isograds and metamorphic facies boundaries of an early Late Cretaceous metamorphic belt trend across the Cenozoic McKinley strand of the Denali system without significant horizontal offsets.

The present geologic make-up of most of southern Alaska is primarily the result of the Talkeetna superterrane, consisting of the previously assembled Peninsular terrane and Wrangellia, colliding with and subsequently being thrust upon the Yukon-Tanana and Nixon Fork terranes of the ancient North American continent in about middle Cretaceous time. The leading edge of the Talkeetna superterrane faces a wide, complexly deformed zone that contains numerous northwestward-[illegible] miniterranes tectonically intermixed with Jurassic and Cretaceous flysch. The flysch is interpreted to have been deposited mostly in the [illegible] and subsequently collapsed oceanic basin between the converging continental blocks. [illegible] collisional Denali fault system developed in Cenozoic time across the already accreted continental margin, in eastern Alaska along an [illegible] Cretaceous suture. (Denali fault, tectonics of southern Alaska).
J. Geophys. Res., Red, Paper 1B1730